ANNA UNIVERSITY, CHENNAI
UNDERGRADUATE CURRICULUM (UNIVERSITY DEPARTMENTS)

Campus: Madras Institute of Technology

Department: Instrumentation Engineering

Programme: B.E. Electronics and Instrumentation Engineering

Regulations: 2023 (Revised 2024), with effect from the AY 2024 – 25 to all the students of UG Programme.

OVERVIEW OF CREDITS

Sem	PCC	PEC	ESC	HSMC	ETC	OEC	SDC	UC	SLC	IOC	Total
I			4	11			7	1			23
II			8	14				1			23
III	12		4	4			2	3			25
IV	19			4					1		24
V	14	6						3		1	24
VI	14	3				3		3		1	24
VII		9			6	3	2			1	21
VIII							8				8
Total	58	18	14	33	6	6	19	11	1	3	172
% of Category	34.3	10.7	8.28	19.5	3.55	3.55	11.24	6.51	0.59	1.78	

CATEGORY OF COURSES

PCC – Professional Core Course
PEC – Professional Elective Course
ETC – Emerging Technology Course
OEC – Open Elective Course
SLC – Self Learning Course
ESC – Engineering Science Course
HSMC – Humanities Science and Management Course
SDC – Skill Development Course
UC – University Course

For Honours & Minor Degree, please refer the Regulations 2023 (Revised 2024).

***TCP –** Total Contact Period(s)

#TYPE OF COURSE

Semester– I							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.	EN23C01	Foundation English	LIT	2-0-2	4	3	HSMC
2.	MA23C01	Matrices and Calculus	T	3-1-0	4	4	HSMC
3.	PH23C01	Engineering Physics	LIT	3-0-2	5	4	HSMC
4.	ME23C01	Engineering Drawing and 3D Modelling	LIT	2-0-4	6	4	SDC
5.	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC
6.	ME23C04	Makerspace	LIT	1-0-4	5	3	SDC
7.	UC23H01	தமிழர் மரபு /Heritage of Tamils	T	1-0-0	1	1	UC
8.		NCC/NSS/NSO/YRC		0-0-2	2	-	UC
				Total Credits		**23**	

***TCP** – Total Contact Period(s)

#**TYPE OF COURSE**

- **LIT** – Laboratory Integrated Theory
- **T** – Theory
- **L** – Laboratory Course
- **IPW** – Internship cum Project Work
- **PW** – Project Work
- **CDP** – Capstone Design Project

Semester– II							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1.	EN23C02	Professional Communication	LIT	2-0-2	4	3	HSMC
2.	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-1-0	4	4	HSMC
3.	PH23C10	Electronic Properties of Materials	T	3-0-0	3	3	HSMC
4.	CY23C01	Engineering Chemistry	LIT	3-0-2	5	4	HSMC
5.	CS23C04	Programming in C	LIT	2-0-4	6	4	ESC
6.	EI23201	Thermodynamics and Fluid Mechanics	TIL	3-0-2	5	4	ESC
7.	UC23H02	தமிழரும் தொழில்நுட்பமும்/Tamils and Technology	T	1-0-0	1	1	UC
8.		Audit Course–I**	-	-	-	-	UC
				Total Credits		**23**	

SEMESTER– III							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1.	MA23C03	Linear Algebra and Numerical Methods	T	3-1-0	4	4	HSMC
2.	EI23301	Analysis of Electric Circuits	TIL	3-0-2	5	4	ESC
3.	EI23302	Electronics for Analog Signal Processing - I	TIL	3-0-2	5	4	PCC
4.	EI23303	Basics of Signals and Systems	TIL	3-0-2	5	4	PCC
5.	EI23304	Electrical Machines	TIL	3-0-2	5	4	PCC
6.	EI23S01	Simulation Tools for Instrumentation Engineering	LIT	1-0-2	3	2	SDC
7.	EI23U01	Standards – E & I	T	1-0-0	1	1	UC
8.	UC23U01	Universal Human Values	LIT	1-0-2	3	2	UC
					TOTAL CREDITS	**25**	

SEMESTER– IV							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1.	MA23C05	Probability and Statistics	T	3-1-0	4	4	HSMC
2.	EI23401	Electronics for Analog Signal Processing-II	TIL	3-0-2	5	4	PCC
3.	EI23402	Digital Systems	TIL	3-0-2	5	4	PCC
4.	EI23403	Instrument Transducers	TIL	3-0-2	5	4	PCC
5.	EI23404	Electrical and Electronic Measurements	T	3-0-2	5	4	PCC
6.	EI23405	Unit Operations in Process Industries	T	3-0-0	3	3	PCC
7.		Audit Course–II**	T	-	-	-	UC
8.	EI23L01	Self-Learning Course	T	1-0-0	1	1	SLC
					TOTAL CREDITS	**24**	

SEMESTER – V (PREFERENCE FOR FOREIGN EXCHANGE)							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1.	EI23501	Industrial Instrumentation - I	TIL	3-0-2	5	4	PCC
2.	EI23502	Discrete Time Signal Processing	T	3-0-0	3	3	PCC
3.	EI23503	Control System Analysis and Design	TIL	3-0-2	5	4	PCC
4.		Professional Elective - I	T	3-0-0	3	3	PEC
5.		Professional Elective - II	T	3-0-0	3	3	PEC
6.	EI23504	Embedded System Design	LIT	1-0-4	5	3	PCC
7.		Industry Oriented Course – I*	-	-	-	1	IOC
8.	UC23E01	Engineering Entrepreneurship Development	T	2-0-2	4	3	UC
TOTAL CREDITS						**24**	
COURSES FOR HONOURS DEGREE							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1.	EI23D01	Capstone Design Project – Level I	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – I				3	
2.		Honours Elective – II				3	
COURSES FOR MINOR DEGREE							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1.		Minor Elective – I		3-0-0	3	3	
2.		Minor Elective – II		3-0-0	3	3	

SEMESTER – VI (PREFERENCE FOR FOREIGN EXCHANGE)							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	EI23601	Industrial Instrumentation-II	TIL	3-0-2	5	4	PCC
2.	EI23602	Process Control	TIL	3-0-2	5	4	PCC
3.	EI23603	Industrial Data Communication	T	3-0-0	3	3	PCC
4.	EI	Professional Elective– III	T	3-0-0	3	3	PEC
5.	EI23604	Industrial Automation Systems	LIT	1-0-4	5	3	PCC
6.		Industry Oriented Course – II	-	-	-	1	IOC
7.		Open Elective – I	T	3-0-0	3	3	OE
8.	EI23U02	Sustainability Course	T	3-0-0	3	3	UC
					Total Credits	**24**	

COURSES FOR HONOURS DEGREE							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	EI23D02	Capstone Design Project – Level II	CDP	CDP	0-0-12	6	SDC
(OR)							
1.		Honours Elective – III	T			3	
2.		Honours Elective – IV	T			3	

COURSES FOR MINOR DEGREE							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.		Minor Elective – III	T			3	
2.		Minor Elective – IV	T			3	

SEMESTER – VII (PREFERENCE FOR FOREIGN EXCHANGE)							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.		Emerging Technology Course - I	T	3-0-0	3	3	ETC
2.		Emerging Technology Course - II	T	3-0-0	3	3	ETC
3.		Professional Elective – IV	T	3-0-0	3	3	PEC
4.		Professional Elective – V	T	3-0-0	3	3	PEC
5.		Professional Elective – VI	T	3-0-0	3	3	PEC
6.		Industry Oriented Course - III	-	-	-	1	IOC
7.		Open Elective – II	T	3-0-0	3	3	OE
8.	EI23701	Summer Internship / Mini Project	**IPW**	0-0-0	0	2	SDC
					TOTAL CREDITS	**21**	

COURSES FOR HONOURS DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURS E TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	EI23D03	Capstone Design Project – Level III	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – V	T	3-0-0	3	3	
2.		Honours Elective – VI	T	3-0-0	3	3	
COURSES FOR MINOR DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURS E TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.		Minor Elective –V	T	3-0-0	3	3	
2.		Minor Elective – VI	T	3-0-0	3	3	

SEMESTER– VIII							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1.	EI23801	Project Work / Internship cum Project Work	PW/IPW	0-0-16	16	8	SDC
					Total Credits	**8**	

TOTAL CREDITS :172

PROGRAMME ELECTIVE COURSE - PEC

Vertical I	Vertical II	Vertical III	Vertical IV	Vertical V	Vertical VI
Industrial Automation	**Modelling and Simulation**	**Advanced Control**	**Applied Instrumentation**	**Health Care Instrumentation**	**Semiconductor Technology and Applications**
Power Electronics, Drives and Control	Mathematical Modelling and System analysis	Advanced topics in PID control	Instrumentation Standards	Biomedical Instrumentation	VLSI Technology
Robotics and Automation	Process Modelling and Simulation	Computer Control of Processes	Fiber Optics and Laser Instrumentation	Medical Imaging Equipment	Real Time Embedded Systems
Safety Instrumented Systems	Virtual Instrumentation	Advanced Process Control	Nano Science and Instrumentation	Diagnostic and Therapeutic Instrumentation	Semiconductor Device Manufacturing
IoT for Industrial Automation	System Identification	Model Based Control	Analytical Instrumentation	Bio-Signal Analysis	Micro Electro Mechanical systems
IoT system Design	State and Parameter Estimation	Non Linear Control	Control Valves	Biomedical Image processing	Nano Electronics
Deep learning	Optimization Techniques	Fault Tolerant Control	Thermal Power Plant Instrumentation	Physiological Control Systems	Green Electronics
Cyber Security for Industrial Automation		Adaptive Control	Instrumentation in Oil and Gas Industry	Rehabilitation Instrumentation	
Reliability And Safety Engineering			Instrumentation for Nuclear Power Plant		
			Fault Detection and Diagnosis		
			Product Conceptualization And Prototyping		

*The student can choose any six subjects from the programme elective courses for Honour Degree

VERTICAL I - INDUSTRIAL AUTOMATION

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23001	Power Electronics, Drives and Control	T	3-0-0	3	3
2.	EI23002	Robotics and Automation	T	3-0-0	3	3
3.	EI23003	Safety Instrumented Systems	T	3-0-0	3	3
4.	EI23004	IoT for Industrial Automation	T	3-0-0	3	3
5.	EI23005	IoT system Design	T	3-0-0	3	3
6.	EI23006	Deep learning	T	3-0-0	3	3
7.	EI23007	Cyber Security for Industrial Automation	T	3-0-0	3	3
8.	EI23008	Reliability And Safety Engineering	T	3-0-0	3	3

VERTICAL II - MODELLING AND SIMULATION

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23009	Mathematical Modelling and System analysis	T	3-0-0	3	3
2.	EI23010	Process Modelling and Simulation	T	3-0-0	3	3
3.	EI23011	Virtual Instrumentation	T	3-0-0	3	3
4.	EI23012	System Identification	T	3-0-0	3	3
5.	EI23013	State and Parameter Estimation	T	3-0-0	3	3
6.	EI23014	Optimization Techniques	T	3-0-0	3	3

VERTICAL III - ADVANCED CONTROL

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23C01	Advanced topics in PID control	T	3-0-0	3	3
2.	EI23015	Computer Control of Processes	T	3-0-0	3	3
3.	EI23016	Advanced Process Control	T	3-0-0	3	3
4.	EI23017	Model Based Control	T	3-0-0	3	3
5.	EI23018	Non Linear Control	T	3-0-0	3	3
6.	EI23019	Fault Tolerant Control	T	3-0-0	3	3
7.	EI23020	Adaptive Control	T	3-0-0	3	3

VERTICAL IV - APPLIED INSTRUMENTATION

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23021	Instrumentation Standards	T	3-0-0	3	3
2.	EI23022	Fiber Optics and Laser Instrumentation	T	3-0-0	3	3
3.	EI23023	Nano Science and Instrumentation	T	3-0-0	3	3
4.	EI23024	Analytical Instrumentation	T	3-0-0	3	3
5.	EI23025	Control Valves	T	3-0-0	3	3
6.	EI23026	Thermal Power Plant Instrumentation	T	3-0-0	3	3
7.	EI23027	Instrumentation in Oil and Gas Industry	T	3-0-0	3	3
8.	EI23028	Instrumentation for Nuclear Power plant	T	3-0-0	3	3

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
9.	EI23029	Fault Detection and Diagnosis	T	3-0-0	3	3
10.	EI23030	Product Conceptualization and Prototyping	T	3-0-0	3	3

VERTICAL V - HEALTH CARE INSTRUMENTATION

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23031	Biomedical Instrumentation	T	3-0-0	3	3
2.	EI23032	Medical Imaging Equipment	T	3-0-0	3	3
3.	EI23033	Diagnostic and Therapeutic Instrumentation	T	3-0-0	3	3
4.	EI23034	Bio-Signal Analysis	T	3-0-0	3	3
5.	EI23035	Biomedical Image processing	T	3-0-0	3	3
6.	EI23036	Physiological Control Systems	T	3-0-0	3	3
7.	EI23037	Rehabilitation Instrumentation	T	3-0-0	3	3

VERTICAL VI - SEMICONDUCTOR TECHNOLOGY AND APPLICATIONS

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23038	VLSI Technology	T	3-0-0	3	3
2.	EI23039	Real Time Embedded Systems	T	3-0-0	3	3
3.	EI23040	Semiconductor Device Manufacturing	T	3-0-0	3	3
4.	EI23041	Micro Electro Mechanical systems	T	3-0-0	3	3
5.	EI23042	Nano Electronics	T	3-0-0	3	3
6.	EI23043	Green Electronics	T	3-0-0	3	3

MINOR ELECTIVES

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23044	Transducer Engineering	T	3-0-0	3	3
2.	EI23045	Process Instrumentation	T	3-0-0	3	3
3.	EI23046	Introduction to Process Control	T	3-0-0	3	3
4.	EI23047	Fundamentals of Industrial Data Communication	T	3-0-0	3	3
5.	EI23048	Analytical Instrumentation Systems	T	3-0-0	3	3
6.	EI23049	Logic and Distributed Control System	T	3-0-0	3	3

EMERGING TECHNOLOGY COURSE - ETC

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23E01	Applied Data Analytics	T	3-0-0	3	3
2.	EI23E02	Machine Learning	T	3-0-0	3	3
3.	EI23E03	Renewable Power Generation Systems	T	3-0-0	3	3
4.	EI23E04	Industry 4.0	T	3-0-0	3	3

OPEN ELECTIVE COURSE - OEC

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1.	EI23901	Introduction to Industrial Instrumentation and Control	T	3-0-0	3	3
2.	EI23902	Introduction to Industrial Data Communication	T	3-0-0	3	3
3.	EI23903	Industrial Automation Systems	T	3-0-0	3	3
4.	EI23904	Introduction to Programmable Logic Controller	T	3-0-0	3	3

EN23C01 FOUNDATION ENGLISH L T P C

2 0 2 3

COURSE OBJECTIVES:

- To develop students' foundational skills in reading, writing, grammar and vocabulary to enable them to understand and produce various forms of communication.
- To enhance students' proficiency in reading comprehension, narrative and comparative writing.
- To comprehend and analyse descriptive texts and visual images
- To articulate similarities and differences in oral and written forms.
- To improve students' proficiency in reading and writing formal letters and emails.

UNIT I BASICS OF COMMUNICATION 6

Reading - Telephone message, bio-note; Writing – Personal profile; Grammar – Simple present tense, Present continuous tense, wh-questions, indirect questions; Vocabulary – Word formation (Prefix and Suffix).

LAB ACTIVITY: 6

Listening – Telephone conversation; Speaking Self-introduction; Telephone conversation – Video conferencing etiquette

UNIT II NARRATION 6

Reading – Comprehension strategies - Newspaper Report, An excerpt from an autobiography; Writing – Narrative Paragraph writing (Event, personal experience etc.); Grammar – Subject-verb agreement, Simple past, Past continuous Tenses; Vocabulary – One-word substitution

LAB ACTIVITY: 6

Listening – Travel podcast; Speaking – Narrating and sharing personal experiences through a podcast

UNIT III DESCRIPTION 6

Reading – A tourist brochure, Travel blogs, descriptive article/excerpt from literature, visual images; Writing –Descriptive Paragraph writing, Grammar – Future tense, Perfect tenses, Preposition; Vocabulary – Descriptive vocabulary

LAB ACTIVITY: 6

Listening – Railway / Airport Announcements, Travel Vlogs; Speaking – Describing a place or picture description

UNIT IV COMPARE AND CONTRAST 6

Reading – Reading and comparing different product specifications - Writing – Compare and Contrast Essay, Coherence and cohesion; Grammar – Degrees of Comparison; Vocabulary – Transition words (relevant to compare and contrast)

LAB ACTIVITY: 6

Listening – Product reviews, Speaking – Product comparison based on product reviews - similarities and differences

UNIT V EXPRESSION OF VIEWS 6

Reading – Formal letters, Letters to Editor ; Writing – Letter writing/ Email writing (Enquiry / Permission, Letter to Editor); Grammar – Compound nouns, Vocabulary – Synonyms, Antonyms

LAB ACTIVITY: 6

Listening – Short speeches; Speaking – Making short presentations (JAM)

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab assessment
- Listening
- Speaking

External Assessment
- End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- Use appropriate grammar and vocabulary to read different types of text and converse appropriately.
- Write coherent and engaging descriptive and comparative essay writing.
- Comprehend and interpret different kinds of texts and audio visual materials
- Critically evaluate reviews and articulate similarities and differences
- Write formal letters and emails using appropriate language structure and format

TEXT BOOKS:

1. "English for Engineers and Technologists" Volume I by Orient Blackswan, 2022
2. "English for Science & Technology - I" by Cambridge University Press, 2023

REFERENCES

1. "Interchange" by Jack C.Richards, Fifth Edition, Cambridge University Press, 2017.
2. "English for Academic Correspondence and Socializing" by Adrian Wallwork, Springer, 2011.
3. "The Study Skills Handbook" by Stella Cortrell, Red Globe Press, 2019
4. www.uefap.com

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		
CO3										√		√
CO4										√		
CO5										√		√

MA23C01 **MATRICES AND CALCULUS**

L	T	P	C
3	1	0	4

OBJECTIVES:

- To develop the use of matrix algebra techniques in solving practical problems.
- To familiarize the student with functions of several variables.
- To solve integrals by using Beta and Gamma functions.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals.
- To acquaint the students with the concepts of vector calculus which naturally arise in many engineering problems.

UNIT I MATRICES 9+3

Eigenvalues and Eigenvectors of a real matrix – Properties of Eigenvalues and Eigenvectors- Cayley-Hamilton theorem (excluding proof) – Diagonalization of matrices - Reduction of Quadratic form to canonical form by using orthogonal transformation - Nature of a Quadratic form.

UNIT II FUNCTIONS OF SEVERAL VARIABLES 9+3

Limit, continuity, partial derivatives – Homogeneous functions and Euler's theorem - Total derivative – Differentiation of implicit functions – Jacobians -Taylor's formula for two variables - Errors and approximations – Maxima and Minima of functions of two variables – Lagrange's method of undermined multipliers.

UNIT III INTEGRAL CALCULUS 9+3

Improper integrals of the first and second kind and their convergence – Differentiation under integrals - Evaluation of integrals involving a parameter by Leibnitz rule – Beta and Gamma functions-Properties – Evaluation of single integrals by using Beta and Gamma functions..

UNIT IV MULTIPLE INTEGRALS 9+3

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of Solids – Change of variables in double and triple integrals-
Evaluation of double and triple integrals by using Beta and Gamma functions.

UNIT V VECTOR CALCULUS 9+3

Gradient of a scalar field, directional derivative – Divergence and Curl – Solenoidal and Irrotational vector fields - Line integrals over a plane curve - Surface integrals – Area of a curved surface – Volume Integral - Green's theorem, Stoke's and Gauss divergence theorems (without proofs)– Verification and applications in evaluating line, surface and volume integrals.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students wherever applicable from the content of the course.

General engineering applications / branch specific applications from the content of each units wherever possible will be introduced to students.

Suggested Laboratory based exercises / assignments / assessments :

Matrices

1. Finding eigenvalues and eigenvectors
2. Verification of Cayley-Hamilton theorem
3. Eigenvalues and Eigenvectors of similar matrices
4. Eigenvalues and Eigenvectors of a symmetric matrix
5. Finding the powers of a matrix
6. Quadratic forms

Functions of Several Variables

1. Plotting of curves and surfaces
2. Symbolic computation of partial and total derivatives of functions

Integral Calculus

1. Evaluation of beta and gamma functions
2. Computation of error function and its complement

Multiple Integrals

1. Plotting of 3D surfaces in Cartesian and Polar forms

Vector Calculus

1. Computation of Directional derivatives
2. Computation of normal and tangent to the given surface

OUTCOMES:

CO 1 :Use the matrix algebra methods for solving practical problems.

CO 2 :Use differential calculus ideas on several variable functions.

CO 3 :Apply different methods of integration in solving practical problems by using Beta and Gamma functions.

CO 4 :Apply multiple integral ideas in solving areas and volumes problems.

CO 5 :Apply the concept of vectors in solving practical problems.

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "'Thomas' Calculus", Pearson Education., New Delhi, 2018.
2. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
3. James Stewart, Daniel K Clegg & Saleem Watson "Calculus with Early Transcendental Functions", Cengage Learning, 6th Edition, New Delhi,2023.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5th Edition, New Delhi, 2017.
4. Narayanan S. and Manicavachagom Pillai T. K., “Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.
5. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
6. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

PH23C01	ENGINEERING PHYSICS	L T P C
	(Common to all branches of B.E/B.Tech Programmes)	3 0 2 4

COURSE OBJECTIVES

- To familiarize with crystal structure, bonding and crystal growth.
- To impart knowledge on Mechanics of Materials.
- To impart knowledge of oscillations, sound and Thermal Physics
- To facilitate understanding of optics and its applications, different types of Lasers and fiber optics.
- To introduce the basics of Quantum Mechanics and its importance.

UNIT I CRYSTAL PHYSICS 9+6

Crystal Bonding – Ionic – covalent – metallic and van der Walls's/ molecular bonding. Crystal systems - unit cell, Bravais lattices, Miller indices - Crystal structures - atomic packing density of BCC, FCC and HCP structures. NaCl, Diamond, Graphite, Graphene, Zincblende and Wurtzite structures - crystal imperfections- point defects - edge and screw dislocations – grain boundaries. Crystal Growth – Czocharalski method – vapor phase epitaxy – Molecular beam epitaxy- Introduction to X-Ray Diffractometer.

1. Determination of Lattice parameters for crystal systems.
2. Crystal Growth – Slow Evaporation method
3. Crystal Growth Sol – Gel Method

UNIT II MECHANICS OF MATERIALS 9+6

Rigid Body – Centre of mass – Rotational Energy - Moment of inertia (M.I)- Moment of Inertia for uniform objects with various geometrical shapes. Elasticity –Hooke's law - Poisson's ratio - stress-strain diagram for ductile and brittle materials – uses- Bending of beams – Cantilever - Simply supported beams - uniform and non-uniform bending - Young's modulus determination - I shaped girders –Twisting couple – Shafts. Viscosity – Viscous drag – Surface Tension.

1. Non-uniform bending -Determination of Young's modulus of the material of the beam.
2. Uniform bending -Determination of Young's modulus of the material of the beam
3. Viscosity – Determination of Viscosity of liquids.

UNIT III OSCILLATIONS, SOUND AND THERMAL PHYSICS 9+6

Simple harmonic motion - Torsional pendulum –- Damped oscillations –Shock Absorber -Forced oscillations and Resonance –Applications of resonance.- Waves and Energy Transport –Sound waves – Intensity level – Standing Waves - Doppler effect and its applications - Speed of blood flow. Ultrasound – applications - Echolocation and Medical Imaging. Thermal Expansion – Expansion joints – Bimetallic strip – Seebeck effect – thermocouple -Heat Transfer Rate – Conduction – Convection and Radiation.

1. Torsional pendulum-Determination of rigidity modulus of wire and moment of inertia of the disc
2. Melde's string experiment - Standing waves.
3. Ultrasonic interferometer – determination of sound velocity and liquids compressibility

UNIT IV OPTICS AND LASERS 9+6

Interference - Thin film interference - Air wedge- Applications -Interferometers–Michelson Interferometer -– Diffraction - CD as diffraction grating – Diffraction by crystals -Polarization - polarizers -– Laser – characteristics – Spontaneous and Stimulated emission- population – inversion - Metastable states - optical feedback - Nd-YAG laser, CO_2 laser, Semiconductor laser - Industrial and medical applications - Optical Fibers – Total internal reflection – Numerical aperture and acceptance angle – Fiber optic communication – Fiber sensors – Fiber lasers.

1. Laser - Determination of the width of the groove of the compact disc using laser.
   Laser Parameters
   Determination of the wavelength of the laser using grating
2. Air wedge -Determination of the thickness of a thin sheet/wire
3. Optical fibre - Determination of Numerical Aperture and acceptance angle
   -Determination of bending loss of fibre.
4. Michelson Interferometer (Demonstration)

UNIT V QUANTUM MECHANICS 9+6

Black body radiation (Qualitative) – Planck's hypothesis – Einstein's theory of Radiation - Matter waves–de Broglie hypothesis - Electron microscope – Uncertainty Principle – The Schrodinger Wave equation (time-independent and time-dependent) – Meaning and Physical significance of wave function - Normalization - Particle in an infinite potential well-particle in a three-dimensional box - Degenerate energy states - Barrier penetration and quantum tunneling - Tunneling microscope.

1. Photoelectric effect – Determination of Planck's constant.
2. Black Body Radiation (Demonstration)
3. Electron Microscope (Demonstration)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the significance of crystal structure and bonding. Learn to grow crystals.
CO2: Obtain knowledge on important mechanical and thermal properties of materials and determine them through experiments.
CO3: Conceptualize and visualize the oscillations and sound.
CO4: Grasp optical phenomenon and their applications in real life.
CO5: Appreciate and evaluate the quantum phenomenon.
CO6 Develop skill set to solve engineering problems and design experiments.

TEXT BOOKS:

1. Raymond A. Serway, John W. Jewett, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2013.
2. D. Halliday, R. Resnick and J. Walker, Principles of Physics. John Wiley & Sons, 10th Edition, 2015.
3. N. Garcia, A. Damask and S. Schwarz, Physics for Computer Science Students, Springer-Verlag, 2012.
4. Alan Giambattista, Betty McCarthy Richardson and Robert C. Richardson, College Physics, McGraw-Hill Higher Education, 2012.

REFERENCES:

1. R. Wolfson, Essential University Physics. Volume 1 & 2. Pearson, 2016.
2. D. Kleppner and R. Kolenkow. An Introduction to Mechanics, McGraw Hill Education, 2017.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1	1								
CO3	3	2	1	1								
CO4	3	2	1	1	1							
CO5	3	2	1	1	1							
CO6	3	2	1	2								

ME23C01 ENGINEERING DRAWING AND 3D MODELLING

L	T	P	C
2	0	4	4

COURSE OBJECTIVES

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

1. Understand and use the engineering curves in engineering applications and projection techniques to construct conic curves, points and lines.
2. Develop skills in projecting surfaces and solids and create 2D models using CAD software.
3. Develop skills in 3D projection and 3D modeling of simple parts manually as well as using CAD software.
4. Understand and apply sectioning techniques to solids and assemble components.
5. Develop skills in lateral surface development and sheet metal design.

INTRODUCTION

Manual drawing tools (Mini Drafter, Set Squares, Protractor, Compass, and different grades of pencil). **‘**BIS’ specifications and rules of Engineering Drawing – Arrows (2H thin line body, HB Filled head and L:W = 3:1 ratio), lettering (Digital fonts, font sizes pertaining to usage and representation), types of line and their syntax (Drawing based – Continuous thin & thick, dashed, dashed dotted and Application based – extension, dimensioning, construction, projection, reference, axis, section, hatching, and break lines), scaling (up, down and equal), and dimensioning. Placing and positioning the ‘A3’ size drawing sheet over the drawing table. Principal planes and projection, Division of line and circle in to equal parts, and construction of polygons

UNIT i: ENGINEERING CURVES, PROJECTION OF POINTS AND LINES 6+12

Construction of conic curves with their tangent and normal – ellipse, parabola, and hyperbola by eccentricity method

Construction of special curves with their tangent and normal – cycloid, epicycloid, and involute

Projection of points and I angle projection of lines inclined to both principal planes by rotating line method and trapezoidal rule – marking their traces.

Lab exercises: Study exercise – Introduction to Sketching (or) Drawing, and modification tools in CAD software (AutoCAD, CREO, CATIA, Solid Works, Inventor, Fusion 360)

Activities based learning: Identification of the curves used in the application given in the flash card, demonstration of the instantaneous centre of rotation of governors with respect to angle of inclination of the arms of the governors

UNIT II PROJECTION OF SURFACES & SOLIDS, AND 2D MODELING 6+12

Projection of surfaces inclined to both the principal planes – polygonal, trapezoidal, rhomboidal and circular

Projection of solids – prisms, pyramids, and axisymmetric solids when the axis inclined to both the principal planes – freely hanging – contour resting condition on either of the planes by rotating object method

Lab exercises: Construction of basic sketches – lines, circle, polygon, spline curves, coils, along with dimensioning. Familiarizing with geometric constraints and their types

Activities based learning: Making the solids using cardboards, shadow mapping and contour drawing at different orientation of the solids using torches,

UNIT III 3D PROJECTION OF SOLIDS AND 3D MODELING OF SIMPLE PARTS 6+12

Free hand sketching – I & III angle projections of engineering parts and components Isometric projection of combination of solids – prisms, pyramids, axisymmetric solids, frustum Perspective projection of prisms, pyramids and axisymmetric solids by visual ray method

Lab exercises: 3D Modeling and 2D drafting of machine parts

Activities based learning: Flipped classroom for Free hand sketching, Jig saw activity for Isometric projection, arts and crafts for perspective view

UNIT IV SECTION OF SOLIDS AND SECTIONED DRAFTING OF ASSEMBLED COMPONENTS 6+12

Section of simple and hollow solids – prisms, pyramids and axisymmetric solids, solids with holes/ slots when the section plane perpendicular to one principal plane and inclined to other principal plane (‘On the axis’ and ‘from the axis’ conditions)

Application based – section of beams (I, T, L, and C), section of pipe bracket, wood joints, composite walls, shells, flange of a coupling and other similar applications

Lab exercises: Assembly of parts with respect to engineering constraints, and sectioned drafting of assembled components

Activities based learning: Making of mitered joint in wood, sectioning the beams in different angles of orientation and identifying the true shape

UNIT V LATERAL SURFACE DEVELOPMENT AND SHEET METAL DESIGN 6+12

Lateral surface development of sectioned solids when the section plane perpendicular to VP and inclined to HP.

Application based – construction of funnel, chimney, dish antenna, door latch, trays, AC vents, lamp shade, commercial packaging boxes with respect to sectioning conditions and other similar applications

Lab exercises: Sheet metal design and drafting, drafting of coils, springs and screw threads

Activities based learning: Fabrication of funnels, chimney, lamp shade, boxes using card boards, ply woods, acrylics

Total: 90 Hours

Note: Activities based learning should not be covered in the regular class hours. It should be given as assignments to the group of maximum 3 members

Question pattern suggestion: Part – A (Either or type) (5 × 16 = 80) & Part – B (Compulsory) (1 × 20 = 20)

COURSE OUTCOME:-

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

CO1: Construct and identify different types of conic curves and special curves, and project the points and lines pertaining to engineering applications

CO2: Project and visualize surfaces and solids in different orientations and utilize the CAD tools for designing.

CO3: Create and draft accurate 3D models and 2D drawings of machine parts manually as well as using CAD softwares

CO4: Determine the true shape of a sectioned solid and draft the assemble parts accordingly

CO5: Develop lateral surfaces of sectioned solids and design sheet metal components

TEXT BOOKS:

1. Engineering Drawing” by N S Parthasarathy and Vela Murali
2. Engineering Drawing and Graphics with Auto CAD” by Venugopal K

REFERENCE BOOKS:

1. “Basic Engineering Drawing: Mechanical Semester Pattern” by Mehta and Gupta
2. "Engineering Drawing” by Basant Agrawal and C M Agrawal
3. “Engineering Drawing With Auto CAD” by B V R Gupta
4. "Engineering Drawing” by P S Gill
5. “Engineering Drawing with an Introduction to AutoCAD” by Dhananjay Jolhe
6. “Engineering Drawing” by M B Shah
7. "Fundamentals of Engineering Drawing” by Imtiaz Hashmi
8. “Computer Aided Engineering Drawing” by S Trymbaka Murthy
9. “CAED : Computer Aided Engineering Drawing for I/II Semester BE/Btech Courses” by Reddy K B
10. “Computer-Aided Engineering Drawing” by Subrata Pal

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2		1				3	1		3	3	3	2
2	3	3	2		2				3	2		3	3	3	2
3	3	3	3	1	2				3	3		3	3	3	2
4	3	3	3	1	3				3	3		3	3	3	2
5	3	3	3	1	3				3	3		3	3	3	2

ME23C03 ENGINEERING MECHANICS L T P C
3 1 0 4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

- Determining the resultant forces acting on a particle in 2D and 3D and for applying methods of equilibrium on a particle in 2D and 3D.
- Evaluating the reaction forces for bodies under equilibrium, for determining the moment of a force, moment of a couple, for resolving force into a force-couple system and for analyzing trusses
- Assessing the centroids of 2D sections / center of gravity of volumes and for calculating area moments of inertia for the sections and mass moment of inertia of solids.
- Evaluating the frictional forces acting at the contact surfaces of various engineering systems and for applying the work-energy principles on a particle.
- Determining kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

UNIT I STATICS OF PARTICLES 9+3

Fundamental Concepts and Principles, Systems of Units, Method of Problem Solutions, Statics of Particles -Forces in a Plane, Resultant of Forces, Resolution of a Force into Components, Rectangular Components of a Force, Unit Vectors. Equilibrium of a Particle- Newton's First Law of Motion, Space and Free-Body Diagrams, Forces in Space, Equilibrium of a Particle in Space.

UNIT II EQUILIBRIUM OF RIGID BODIES AND TRUSSES 9+3

Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Moment of a Force about a Point, Varignon's Theorem, Rectangular Components of the Moment of a Force, Scalar Product of Two Vectors, Mixed Triple Product of Three Vectors, Moment of a Force about an Axis, Couple - Moment of a Couple, Equivalent Couples, Addition of Couples, Resolution of a Given Force into a Force -Couple system, Further Reduction of a System of Forces, Equilibrium in Two and Three Dimensions - Reactions at Supports and Connections – Analysis of Trusses – Method of Joints and Method of Sections.

UNIT III DISTRIBUTED FORCES 9+3

Centroids of lines and areas – symmetrical and unsymmetrical shapes, Determination of Centroids by Integration, Theorems of Pappus-Guldinus, Distributed Loads on Beams, Centre of Gravity of a Three-Dimensional Body, Centroid of a Volume, Composite Bodies, Determination of Centroids of Volumes by Integration.

Moments of Inertia of Areas and Mass - Determination of the Moment of Inertia of an Area by Integration , Polar Moment of Inertia , Radius of Gyration of an Area , Parallel-Axis Theorem , Moments of Inertia of Composite Areas, Moments of Inertia of a Mass - Moments of Inertia of Thin Plates , Determination of the Moment of Inertia of a Three-Dimensional Body by Integration.

UNIT IV FRICTION AND WORK PRINCIPLES 9+3

The Laws of Dry Friction. Coefficients of Friction, Angles of Friction, Wedges, Wheel Friction. Rolling Resistance, Ladder friction. Work of a Force, Kinetic Energy of a Particle, Principle of Work and Energy, Principle of Impulse and Momentum, Impact, Method of Virtual Work - Work of a Force, Potential Energy, Potential Energy and Equilibrium.

UNIT V DYNAMICS OF PARTICLES AND RIGID BODIES 9+3

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods – Kinematics of Rigid Bodies and Plane Kinetics.

TOTAL : 60 Periods

COURSE OUTCOMES:

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

1. To determine the resultant forces acting on a particle in 2D and 3D and to apply methods of equilibrium on a particle in 2D and 3D.
2. Evaluate the reaction forces for bodies under equilibrium, to determine moment of a force, moment of a couple, to resolve force into a force-couple system and to analyze trusses
3. Assess the centroids of 2D sections / center of gravity of volumes and to calculate area moments of inertia for the sections and mass moment of inertia of solids.
4. Evaluate the frictional forces acting at the contact surfaces of various engineering systems and apply the work-energy principles on a particle. evaluate the kinetic and kinematic parameters of a particle.
5. Determine kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

TEXT BOOKS:

1. Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, Sanjeev Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education., 12th Edition, 2019.
2. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	3									3		
2	3	3	2	3									3		
3	3	3	2	3									3		
4	3	3	2	3									3		
5	3	3	2	3									3		
Avg	3	3	2	3									3		

ME23C04 **MAKERSPACE**

L	T	P	C
1	0	4	3

COURSE OBJECTIVES:

1. To practice the usage of various tools towards assembly and dis-assembly of different items / equipment.
2. To make simple part / component using welding processes.
3. To train on the basic wiring practices of boards, machines, etc.
4. To provide a hands-on experience on the use of electronic components, equipment, sensors and actuators.
5. To expose to modern computer tools and advanced manufacturing / fabrication processes.

LIST OF ACTIVITIES **1L,4P**

(A). Dis-assembly & Assembly Practices

i. Tools and its handling techniques.
ii. Dis-assembly and assembly of home appliances – Grinder Mixer Grinder, Ceiling Fan, Table Fan & Washing Machine.
iii. Dis-assembly and assembly of Air-Conditioners & Refrigerators.
iv. Dis-assembly and assembly of a Bicycle.

(B). Welding Practices

i. Welding Procedure, Selection & Safety Measures.
ii. Power source of Arc Welding – Gas Metal Arc Welding & Gas Tungsten Arc Welding processes.
iii. Hands-on session of preparing base material & Joint groove for welding.
iv. Hands-on session of MAW, GMAW, GTAW, on Carbon Steel & Stainless Stell plates / pipes, for fabrication of a simple part.

(C). Electrical Wiring Practices

i. Electrical Installation tools, equipment & safety measures.
ii. Hands-on session of basic electrical connections for Fuses, Miniature Circuit Breakers and Distribution Box,
iii. Hands-on session of electrical connections for Lightings, Fans, Calling Bells.

iv. Hands-on session of electrical connections for Motors & Uninterruptible Power Supply.

(D). Electronics Components / Equipment Practices

i. Electronic components, equipment & safety measures.

ii. Dis-assembly and assembly of Computers.

iii. Hands-on session of Soldering Practices in a Printed Circuit Breaker.

iv. Hands-on session of Bridge Rectifier, Op-Amp and Transimpedance amplifier.

v. Hands-on session of integration of sensors and actuators with a Microcontroller.

vi. Demonstration of Programmable Logic Control Circuit.

(E). Contemporary Systems

i. Demonstration of Solid Modelling of components.

ii. Demonstration of Assembly Modelling of components.

iii. Fabrication of simple components / parts using 3D Printers.

iv. Demonstration of cutting of wood / metal in different complex shapes using Laser Cutting Machine.

TOTAL: 75 Periods (15 Lecture + 60 Practical)

COURSE OUTCOMES:

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

CO1: Assemble and dis-assemble various items / equipment.
CO2: Make simple parts using suitable welding processes.
CO3: Setup wiring of distribution boards, machines, etc.
CO4: Utilise the electronic components to fabricate a simple equipment, aided with sensors and actuators.
CO5: Take advantage of modern manufacturing practices.

REFERENCES:

1. Stephen Christena, Learn to Weld: Beginning MIG Welding and Metal Fabrication Basics, Crestline Books, 2014.
2. H. Lipson, Fabricated - The New World of 3D Printing, Wiley, 1st edition, 2013.
3. Code of Practice for Electrical Wiring Installations (IS 732:2019)
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press, 7th ed. (Indian edition), 2017.

5. Mazidi, Naimi, Naimi, AVR Microcontroller and Embedded Systems: Using Assembly and C, Pearson India, 1st edition 2013.
6. Visualization, Modeling, and Graphics for Engineering Design, D.K. Lieu, S.A. Sorby, Cengage Learning; 2nd edition.

UC23H01	தமிழர் மரபு	L T P C
		1 0 0 1

அலகு I **மொழி மற்றும் இலக்கியம்**: 3

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II **மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை – சிற்பக் கலை**: 3

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரிமுனையில் திருவள்ளுவர் சிலை – இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III **நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்**: 3

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV **தமிழர்களின் திணைக் கோட்பாடுகள்**: 3

தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V **இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு**: 3

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)

6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H01	HERITAGE OF TAMILS	L T P C
		1 0 0 1

UNIT I LANGUAGE AND LITERATURE 3

Language Families in India - Dravidian Languages – Tamil as aClassical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.

UNIT II HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE 3

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III FOLK AND MARTIAL ARTS 3

Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leatherpuppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

UNIT IV THINAI CONCEPT OF TAMILS 3

Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.

UNIT V CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE 3

Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல்

துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

NCC Credit Course Level 1*

UC23P01 **(ARMY WING) NCC Credit Course Level - I**

L	T	P	C
2	0	0	2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour ‘Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P02	**(NAVAL WING) NCC Credit Course Level – I**	**L T P C** **2 0 0 2**

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P03	**(AIR FORCE WING) NCC Credit Course Level – I**	**L T P C**
		2 0 0 2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

EN23C02 PROFESSIONAL COMMUNICATION

L	T	P	C
2	0	2	3

COURSE OBJECTIVES:

- To read and comprehend different forms of official texts.
- To develop students' writing skills in professional context.
- To actively listen, read and understand written and oral communication in a professional context.
- To comprehend and analyse the visual content in authentic context.
- To write professional documents with clarity and precision

UNIT I CAUSE AND EFFECT 6

Reading – Newspaper articles on Social and Environmental issues; Writing – Instructions, Cause and effect essay; Grammar - Modal verbs; Vocabulary – Cause and effect, Idioms

LAB ACTIVITY: 6

Listening and Speaking – Listen to news reports and summarise in oral form.

UNIT II CLASSIFICATION 6

Reading – An article, social media posts and classifying based on the content; Writing – Definition, Note making, Note taking (Cornell notes etc.) and Summarising; Grammar – Connectives; Vocabulary – Phrasal verbs

LAB ACTIVITY: 6

Listening and speaking: Social interaction (Conversation including small talk)

UNIT III PROBLEM AND SOLUTION 6

Reading – Visual content (Tables/charts/graphs) for comprehension; Writing - Problem and Solution Essay; Grammar – If conditionals; Vocabulary – Sequential words.

LAB ACTIVITY: 6

Listening – Group discussion; Speaking – Participating in a group discussion

UNIT IV REPORT 6

Reading – Formal report on accidents (industrial/engineering); Writing – Industrial Accident report; Grammar – Active and passive voice, Direct and Indirect speech; Vocabulary – Numerical adjectives.

LAB ACTIVITY: 6

Listening / watching – Television documentary and discussing its content, purpose etc.

UNIT V JOB APPLICATION AND INTERVIEW 6

Reading - Job advertisement and company profile; Writing – Job application (cover letter and CV) Grammar – Mixed Tenses; Vocabulary – Collocations related to work environment

LAB ACTIVITY: 6

Listening – Job interview; Speaking – Mock interviews

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab Assessment
- Group discussion (Peer assessment)
- Listening

External Assessment
End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- To apply appropriate language structure and vocabulary to enhance both spoken and written communication in formal contexts.
- Comprehend different forms of official documents
- Write professional documents coherently and cohesively.
- Interpret verbal and graphic content in authentic context
- Analyse and evaluate verbal and audio visual materials.

TEXT BOOKS:

1. "English for Engineers and Technologists" Volume 2 by Orient Blackswan, 2022
2. "English for Science & Technology - II" by Cambridge University Press, 2023.

REFERENCES:

1. "Communicative English for Engineers and Professionals" by Bhatnagar Nitin, Pearson India, 2010.
2. "Take Off – Technical English for Engineering" by David Morgan, Garnet Education, 2008. 3. "Advanced Communication Skills" by Mathew Richardson, Charlie Creative Lab, 2020.
4. www.uefap.com

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		√
CO3										√		√
CO4										√		√
CO5										√		√

MA23C02	ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORM TECHNIQUES	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To acquaint the students with Differential Equations which are significantly used in engineering problems.
- To make the students to understand the Laplace transforms techniques.
- To develop the analytic solutions for partial differential equations used in engineering by Fourier series.
- To acquaint the student with Fourier transform techniques used in wide variety of situations in which the functions used are not periodic.
- To develop Z- transform techniques in solving difference equations.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9+3

Homogeneous linear ordinary differential equations of second order -superposition principle - general solution- Particular integral - Operator method - Solution by variation of parameters - Method of undetermined coefficients - Homogeneous equations of Euler–Cauchy and Legendre's type – System of simultaneous linear differential equations with constant coefficients.

UNIT II LAPLACE TRANSFORMS 9+3

Existence theorem - Transform of standard functions – Transform of Unit step function and Dirac delta function – Basic properties - Shifting theorems - Transforms of derivatives and integrals – Transform of periodic functions - Initial and Final value theorem - Inverse Laplace transforms- Convolution theorem (without proof) – Solving Initial value problems by using Laplace Transform techniques.

UNIT III FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half-range Sine and Cosine series – Complex form of Fourier series – Parseval's identity – Computation of harmonics.

UNIT IV FOURIER TRANSFORMS 9+3

Fourier integral theorem – Fourier transform pair - Fourier sine and cosine transforms – Properties – Transform of elementary functions – Inverse Fourier Transforms - Convolution theorem (without proof) – Parsevals's identity.

UNIT V Z – TRANSFORM AND DIFFERENCE EQUATIONS 9+3

Z-transform – Properties of Z-transform – Inverse Z-transform – Convolution theorem – Evaluation of Inverse Z transform using partial fraction method and convolution theorem - Initial and final value theorems – Formation of difference equations – Solution of difference equations using Z - transform.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.
Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.
Suggested Laboratory based exercises / assignments / assessments :
Ordinary differential equations

1. Symbolic computation of linear ordinary differential equations
2. Solving System of simultaneous linear differential equations using ODE SOLVER

Laplace transforms

1. Symbolic computation of Laplace transform and Inverse Laplace transform
2. Plotting Laplace transforms

Fourier Series

1. Symbolic computation of Fourier Coefficients
2. Computation of harmonics
3. Plotting truncated Fourier Series

Fourier Transform

1. Symbolic computation of Fourier Transforms
2. Plotting truncated Fourier Transforms

Z – transform

1. Symbolic computation of Z-Transforms

OUTCOMES:

CO1 :Solve higher order ordinary differential equations which arise in engineering applications.
CO2 :Apply Laplace transform techniques in solving linear differential equations.
CO3 :Apply Fourier series techniques in engineering applications.
CO4 :Understand the Fourier transforms techniques in solving engineering problems.
CO5 :Understand the Z-transforms techniques in solving difference equations.

TEXT BOOKS:

1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10^{th} Edition, Wiley India Pvt Ltd., New Delhi, 2018.

REFERENCES:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5 th Edition, New Delhi, 2017.
4. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
5. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

PH23C10	ELECTRONIC PROPERTIES OF MATERIALS (**Common to EEE and EI Branches**)	L T P C 3 0 0 3

OBJECTIVES:

- To understand the electrical properties of materials and the classification of solids.
- To instill knowledge on the physics of semiconductors, and device applications
- To install knowledge on the physics of dielectric and magnetic materials and device applications
- To establish a sound knowledge on different optical properties of materials, optical displays and applications
- To in calculate an idea of the significance of nanostructures, quantum confinement and ensuing nanodevice applications.

UNIT I ELECTRICAL PROPERTIES OF MATERIALS 9

Classical free electron theory - Expression for electrical conductivity–Thermal conductivity, expression Wiedemann – Franz law - Quantum free electron theory - Degenerate energy states– Density of States - Fermi-Dirac statistics – Conduction electron density – Electron in a periodic potential – Energy bands in solids – Conductors – Semiconductors – Insulators – tight-binding approximation- Electron effective mass– the concept of hole.

UNIT II SEMICONDUCTORS AND TRANSPORT PHYSICS 9

Intrinsic Semiconductors – Energy band diagram – direct and indirect bandgap semiconductors– Carrier concentration in intrinsic semiconductors – Determination of band gap – extrinsic semiconductors - Carrier concentration in N-type & P-type semiconductors – Variation of carrier concentration with temperature – Carrier transport in Semiconductors: Drift, mobility, diffusion and carrier lifetime – Hall effect -devices and sensors – Ohmic contacts – Peltier coolers - Schottky diode – solar cell.

UNIT III DIELECTRIC AND MAGNETIC PROPERTIES OF MATERIALS 9

Electric Dipole moment and polarization vector, Polarization mechanisms: electronic, ionic, orientational, interfacial and total polarization - dielectric constant and dielectric loss - dielectric strength and insulation – Applications of dielectric materials. Origin of Magnetism - atomic magnetic moments – Bohr magneton- magnetic materials: diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism - Ferromagnetism – origin and exchange interaction - Domain theory -saturation magnetization and curie temperature-domain walls and motion – Hysteresis –- soft and hard magnetic materials – GMR effect - GMR materials – Applications – Magnetic data storage.

UNITI V OPTICAL PROPERTIES OF MATERIALS 9

Light waves in a homogeneous medium - refractive index - dispersion: refractive index-wavelength behavior - group velocity and group index - Fresnel's equations: reflection and transmission coefficients, Absorption, emission and scattering of light – Luminescence – Phosphors LED's : Principle and working – white LED, Laser diode – optical Amplifiers - Organic LED and Plasma light emitting devices, LCD - Homojunction and Hetero junction laser diodes. Optical data storage techniques(CD, DVD and Blue-ray disc,

UNIT V NANODEVICES 9

Electron density in a conductor – Significance between Fermi energy and volume of the material – Quantum confinement – Quantum structures – Density of states for quantum wells, wires and dots – Band gap of nanomaterials –Tunneling – Single electron phenomena – Single electron Transistor. The conductivity of metallic nanowires – Ballistic transport – Quantum resistance and conductance – Carbon nanotubes: Properties and applications Transporters – Spintronic devices and application.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completing the above subject, students will have

CO1: Knowledge of the electrical properties of materials

CO2: Acquire an adequate understanding of semiconductor physics and the functioning of semiconductor devices

CO3: Come to have firm knowledge of the dielectric and magnetic properties of materials and their applications

CO4: Understand the optical properties of materials and working principles of various optical devices

CO5: Appreciate the importance of nanotechnology, the physics of nanodevices, low-dimensional structures and their applications

REFERENCES:

1. W.D.Callitser and D.G. Rethwish. Materials Science and Engineering. John Wiley & Sons, 2014.
2. S.O.Kasap. Principles of Electronic Materials and Devices. McGraw Hill Education, 2017.
3. R.F.Pierret. Semiconductor Device Fundamentals. Pearson, 2006.
4. N.Garcia, A. Damask and S.Schwarz. Physics for Computer Science Students. Springer-Verlag, 2012.
5. G.W. Hanson, Fundamentals of Nanoelectronics. Pearson Education, 2009.
6. J. Wilson and J.F.B. Hawkes. Optoelectronics. Pearson Education, 2018.
7. N. Gershenfeld. The Physics of Information Technology. Cambridge University Press, 2011.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	1	-	-	-	-	-	-	-
CO2	2	2	1	1	1	-	-	-	-	-	-	-
CO3	2	2	1	2	1	-	-	-	-	-	-	-
CO4	2	2	2	1	1	-	-	-	-	-	-	-
CO5	2	1	2	2	1	-	-	-	-	-	-	-
Avg.	2	1.6	3.5	3.5	1	-	-	-	-	-	-	-

1-Low, 2-Medium, 3-High, '-"- no correlation

CY23C01 **ENGINEERING CHEMISTRY** **L T P C**

3 0 2 4

UNIT I WATER TECHNOLOGY

Water – sources and impurities – water quality parameters: colour, odour, pH, hardness, alkalinity, TDS, COD, BOD, and heavy metals. Boiler feed water – requirement – troubles (scale & sludge, caustic embrittlement, boiler corrosion and priming & foaming. Internal conditioning – phosphate, Calgon, and carbonate treatment. External conditioning – demineralization. Municipal water treatment (screening, sedimentation, coagulation, filtration, disinfection-ozonolysis, UV treatment, chlorination), Reverse Osmosis – desalination.

PRACTICAL:

- Estimation of HCl using Na_2CO_3 as the primary standard
- Determination of alkalinity in the water sample.
- Determination of hardness of water by EDTA method.
- Determination of DO content of water sample by Winkler's method.

UNIT II NANOCHEMISTRY

Basics-distinction between molecules, nanomaterials and bulk materials; size-dependent properties (optical, electrical, mechanical, magnetic and catalytic). Types –nanoparticle, nanocluster, nanorod, nanowire and nanotube. Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro-spinning. Characterization - Scanning Electron Microscope and Transmission Electron Microscope - Principle and instrumentation (block diagram). Applications of nanomaterials – medicine including AYUSH, automobiles, electronics, and cosmetics.

PRACTICAL:

- Preparation of nanoparticles by Sol-Gel method/sonication method.
- Preparation of nanowire by Electrospinning.
- Study of morphology of nanomaterials by scanning electron microscopy

UNIT III CORROSION SCIENCE

Introduction to corrosion – chemical and electrochemical corrosions – mechanism of electrochemical and galvanic corrosions – concentration cell corrosion-soil, pitting, inter-granular, water line, stress and microbiological corrosions-galvanic series-factors influencing corrosion-measurement of corrosion rate. Electrochemical protection – sacrificial anodic protection and impressed current cathodic protection. Protective coatings-metallic coatings (galvanizing, tinning), organic coatings (paints). Paints: Constituents and functions.

PRACTICAL:

- Corrosion experiment-weight loss method.
- Salt spray test for corrosion study.
- Corrosion prevention by electroplating.
- Estimation of corroded Iron by Potentiometry/UV-visible spectrophotometer

UNIT IV ENERGY SOURCES

Electrochemical cell, redox reaction, electrode potential – oxidation and reduction potential. Batteries – Characteristics; types of batteries; primary battery (dry cell), secondary battery (lead acid, lithium-ion battery) and their applications. Emerging energy sources – metal hydride battery, hydrogen energy, Fuel cells – H_2-O_2 fuel cell. Supercapacitors –Types and Applications, Renewable Energy: solar heating and solar cells. Recycling and disposal of batteries.

PRACTICAL:

- Study of components of Lead acid battery.
- Measurement of voltage in a photovoltaic cell.
- Working of $H_2 – O_2$ fuel cell

UNIT V POLYMER CHEMISTRY

Introduction: Functionality-degree of polymerization. Classification of polymers (Source, Structure, Synthesis and Intermolecular forces). Mechanism of free radical addition polymerization. Properties of polymers: Tg, tacticity, molecular weight-number average, weight average, viscosity average and polydispersity index (Problems). Techniques of polymerization: Bulk, emulsion, solution and suspension. Compounding and Fabrication Techniques: Injection, Extrusion, Blow and Calendaring. Polyamides, Polycarbonates and Polyurethanes – structure and applications. Recycling of polymers.

PRACTICAL:

- Determination of molecular weight of a polymer using Ostwald viscometer.
- Preparation of a polymer.
- Determination of molecular weight by Gel Permeation Chromatography.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: To demonstrate knowledge of water quality in various industries and develop skills in analyzing water quality parameters for both domestic and industrial purposes.

CO2: To identify and apply fundamental concepts of nanoscience and nanotechnology for engineering and technology applications, and to develop skills in synthesizing nanomaterials and studying their morphology.

CO3: To apply fundamental knowledge of corrosion protection techniques and develop skills to conduct experiments for measuring and preventing corrosion.

CO4: To study the fundamentals of energy storage devices and develop skills in constructing and experimenting with batteries.

CO5: To recognize and apply basic knowledge of different types of polymeric materials and develop skills in preparing and determining their applications for futuristic material fabrication needs.

TEXT BOOKS:

1. Jain P. C. & Monica Jain., “Engineering Chemistry”, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2015.
2. Sivasankar B., “Engineering Chemistry”, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2012.
3. Dara S.S., “A Textbook of Engineering Chemistry”, Chand Publications, 2004.
4. Laboratory Manual - Department of Chemistry, CEGC, Anna University (2023).

REFERENCES:

1. Schdeva M.V., “Basics of Nano Chemistry”, Anmol Publications Pvt Ltd, 2011.
2. Friedrich Emich, “Engineering Chemistry”, Medtech, 2014.
3. Gowariker V.R., Viswanathan N.V. and Jayadev Sreedhar, “Polymer Science” New AGE

International Publishers, 2009.

4. Vogel's Textbook of Quantitative Chemical Analysis (8th edition, 2014).

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	3	-	-	-	-	-
CO2	3	-	2	-	2	-	3	-	-	-	-	-
CO3	3	3	2	-	2	-	3	-	-	-	-	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-
CO5	3	-	-	-	-	-	3	-	-	-	-	-
Avg	3	3	-	-	-	-	3	-	-	-	-	-

1' = Low; '2' = Medium; '3' = High

CS23C04	PROGRAMMING IN C	L T P C
		2 0 4 4

UNIT I BASICS OF C PROGRAMMING 6+12

Introduction to programming paradigms –- Structure of C program - C programming: Data Types - Constants - Keywords - Operators: Precedence and Associativity - Expressions - Input/Output statements, Assignment statements - Decision making statements - Switch statement.

PRACTICALS

1. Designing programs with algorithms/flowchart
2. Programs for i/o operations with different data types

UNIT II LOOP CONTROL STATEMENTS AND ARRAYS 6+12

Iteration statements: For, while, Do-while statements, nested loops, break & continue statements - Introduction to Arrays: Declaration, Initialization - One dimensional array -Two dimensional arrays – Searching and sorting in Arrays – Strings – string handling functions - array of strings

PRACTICALS

1. Programs using various operators
2. Programs using decision making and branching statements
3. Programs using for, while, do-while loops and nested loops.
4. Programs using arrays and operations on arrays.
5. Programs implementing searching and sorting using arrays
6. Programs implementing string operations on arrays

UNIT III FUNCTIONS AND POINTERS 6+12

Modular programming - Function prototype, function definition, function call, Built-in functions – Recursion – Recursive functions - Pointers - Pointer increment, Pointer arithmetic - Parameter passing: Pass by value, Pass by reference, pointer and arrays, dynamic memory allocation

PRACTICALS

1. Programs using functions
2. Programs using recursion
3. Programs using pointers & strings with pointers
4. Programs using Dynamic Memory Allocation

UNIT IV STRUCTURES AND UNION 6+12

Storage classes, Structure and union, Features of structures, Declaration and initialization of structures, array of structures, Pointer to structure, structure and functions, typedef , bit fields , enumerated data types, Union.

PRACTICALS

1. Programs using Structures
2. Programs using Unions
3. Programs using pointers to structures and self-referential structures.

UNIT V MACROS AND FILE PROCESSING 6+12

Preprocessor directives – Simple and Conditional macros with and without parameters - Files - Types of file processing: Sequential and Random access – File operations – read, write & seek.

PRACTICALS

1. Programs using pre-processor directives & macros
2. Programs to handle file operations
3. Programs to handle file with structure

TOTAL: 90 (30+60) PERIODS

TEXT BOOKS:

1. Kernighan, B.W and Ritchie,D.M, "The C Programming language", Second Edition, Pearson Education, 2015.
2. Yashwant Kanetkar, Let us C, 17th Edition, BPB Publications, 2020.

REFERENCE BOOKS:

1. Pradip Dey, Manas Ghosh, "Computer Fundamentals and Programming in C", Second Edition, Oxford University Press, 2013.
2. Ashok N Kamthane, Programming in C, Pearson, Third Edition, 2020
3. Reema Thareja, "Programming in C", Oxford University Press, Second Edition, 2016.
4. Paul Deitel and Harvey Deitel, "C How to Program with an Introduction to C++", Eighth edition, Pearson Education, 2018.
5. Byron S. Gottfried, "Schaum's Outline of Theory and Problems of Programming with C'" McGraw-Hill Education, 1996.
6. Anita Goel and Ajay Mittal, "Computer Fundamentals and Programming in C", 1st Edition, Pearson Education, 2013.

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1: Write simple C programs using basic constructs.

CO2: Design searching and sorting algorithms using arrays and strings.

CO3: Implement modular applications using Functions and pointers.

CO4: Develop and execute applications using structures and Unions.

CO5: Illustrate algorithmic solutions in C programming language using files.

Total Hours: 90 (30+60)

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	1	3	2	1	-	-	-	2	-	3	1	2	2
2	2	1	1	3	2	1	-	-	-	-	-	3	1	2	2
3	2	2	1	3	2	1	-	-	3	-	3	3	1	2	2
4	2	1	1	3	2	1	-	-	3	-	3	3	1	2	2
5	2	3	1	3	2	1	-	-	-	2	3	3	1	2	2

1 - low, 2 - medium, 3 – high

EI23201 THERMODYNAMICS AND FLUID MECHANICS

	L	T	P	C
	3	0	2	4

UNIT I BASIC CONCEPTS AND LAWS OF THERMODYNAMICS 9L, 5P

Thermodynamic system and surroundings – properties of system – State and Equilibrium Forms of energy – Quasi static process – Zeroth law of thermodynamics – Work and heat transfer – Path and point functions – First law of thermodynamics applied to open systems – SFEE equation and its applications. Second law of thermodynamics applied to Heat engines, Refrigerators& Heat pumps.

PRACTICALS

Determination of Specific heat of a solid.

UNIT II AIR STANDARD CYCLES AND COMPRESSORS 9L,15P

Cycle, Carnot cycle, Otto, Diesel, Dual combustion and Brayton cycles. Air standard efficiency. Mean effective pressure. Comparison of cycles, Efficiency versus compression ratio, For the same compression ratio and the same heat input

PRACTICALS

Performance test on 4 stroke engine.
COP test on vapor compression refrigeration test rig.
Free and forced convective heat transfer from a flat plate.

UNIT III BASIC CONCEPT OF FLUID MECHANICS & FLOW OF FLUIDS 9

Fluid: Properties and types. Pressure: laws of pressure, types of pressure, pressure measurement using manometers and mechanical gauges. Viscosity: Kinematic and dynamic viscosity. Fluid kinematics and dynamics – Types of fluid flow – velocity – rate equation of continuity – head of a liquid – Bernoulli's theorem

UNIT IV DIMENSIONAL AND MODEL ANALYSIS 15

Dimension – need for dimensional analysis, Rayleigh's and Buckingham's method applied to flow problems, limitation of dimensional analysis. Model analysis – similitude, dimensionless numbers and their significance, similarity laws, model studies, limitation of scale models.

UNIT V HYDRAULIC MACHINES 9L, 10P

Introduction and classification of hydraulic machines. Reciprocating pump: constructional details, working principle, co-efficient of discharge, slip, power required. Centrifugal pump: classification and working principle, specific speed. Turbines: classification, working principle of a Pelton wheel turbine

PRACTICALS

Determination of performance characteristics of a reciprocating pump.
Determination of performance characteristics of a centrifugal pump.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

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

CO1 Apply laws of thermodynamics for different applications. (L3)

CO2 Use the basic concepts and methodologies for the analysis of air standard cycles. (L4)
CO3 Apply laws of fluid mechanics for different applications. (L2)
CO4 Understand the need of dimensional and model analysis. (L2)
CO5 Understand the working of pumps and turbines. (L1)

TEXTBOOKS:

1. Nag, P.K., “Engineering Thermodynamics”, Tata McGraw-Hill Co. Ltd., 2007.
2. Chattopadhyay, P., “Engineering Thermodynamics”, Oxford University Press, New Delhi, 2010.
3. Rathakrishnan, E., “Fundamentals of Engineering Thermodynamics” Prentice-Hall India, 2005.
4. Bansal. R.K., “Fluid Mechanics and Hydraulics Machines”, Lakshmi Publications Pvt. Ltd., New Delhi, 9th Edition, 2015.

REFERENCES:

1. Reynold, “Thermodynamics”, Int. Student Edition, McGraw-Hill Co. Ltd., 1990.
2. Ramalingam, K.K., “Thermodynamics”, Sci-Tech Publications, 2006.
3. Holman, J.P, “Heat Transfer”, McGraw-Hill, 3rd Edition, 2007.
4. Shames, I.H., “Mechanics of Fluids”, Kogakusha, Tokyo, 1998.
5. Kumar, K.L., “Fluid Mechanics”, Eurasia Publishers, 1990.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	3	3	-	-	3	-	1	-	1	-	2	3	-	-
CO2	2	3	3	-	-	3	-	1	-	1	-	2	3	-	-
CO3	3	-	3	-	-	-	-	1	-	1	-	2	3	-	-
CO4	-	-	3	-	-	-	-	1	-	1	-	-	-	-	-
CO5	2	3	3	-	-	3	-	1	-	1	-	2	-	-	-
Avg	2.25	3	3	-	-	3	-	1	-	1	-	2	3	-	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

UC23H02 தமிழரும் தொழில்நுட்பமும்/Tamils and Technology L T P C
1 0 0 1

அலகு I <u>நெசவு மற்றும் பானைத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II <u>வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு- சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும், கோவில்களும் – சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் – நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக் கலை.

அலகு III <u>உற்பத்தித் தொழில் நுட்பம்</u>: 3

கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத்துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV <u>வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்</u>: 3

அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்.

அலகு V <u>அறிவியல் தமிழ் மற்றும் கணித்தமிழ்</u>: 3

அறிவியல் தமிழின் வளர்ச்சி –கணித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின் நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும்
   கல்வியியல் பணிகள் கழகம்).

2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

TAMILS AND TECHNOLOGY

L	T	P	C
1	0	0	1

UNIT I WEAVING AND CERAMIC TECHNOLOGY 3

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

UNIT II DESIGN AND CONSTRUCTION TECHNOLOGY 3

Designing and Structural construction House & Designs in household materials during Sangam Age -Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period -Type study (Madurai Meenakshi Temple)- Thirumalai NayakarMahal -ChettiNadu Houses, Indo-Saracenic architecture at Madras during British Period.

UNIT III MANUFACTURING TECHNOLOGY 3

Art of Ship Building - Metallurgical studies -Iron industry - Iron smelting, steel -Copper and gold-Coins as source of history - Minting of Coins – Beads making-industries Stonebeads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

UNIT IV AGRICULTURE ANDIRRIGATION TECHNOLOGY 3

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompuof Chola Period,Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing -KnowledgeofSea -Fisheries – Pearl - Conche diving - Ancient Knowledge ofOcean -KnowledgeSpecificSociety.

UNIT V SCIENTIFIC TAMIL & TAMIL COMPUTING 3

Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

MA23C03 LINEAR ALGEBRA AND NUMERICAL METHODS

L	T	P	C
3	1	0	4

OBJECTIVES:

- To understand Vector spaces and its basis and dimension.
- To understand the linear maps between vector spaces and their matrix representations.
- To understand the diagonalizatition of a real symmetric matrix.
- To understand Inner product spaces and its projections.
- To understand numerical techniques for solving linear systems, eigenvalue problems and generalized inverses.

UNIT I VECTORSPACES 9+3

Vector Spaces – Subspaces – Linear Combinations - Linear Span – Linear Dependence - Linear Independence – Bases and Dimensions.

UNIT II LINEAR TRANSFORMATIONS 9+3

Linear Transformation – Null Space, Range Space - Dimension Theorem - Matrix representation of Linear Transformation – Eigenvalues and Eigenvectors of Linear Transformation – Diagonalization of Linear Transformation – Application of Diagonalization in Linear System of Differential Equations.

UNIT III INNER PRODUCT SPACES 9+3

Inner Products and Norms - Inner Product Spaces - Orthogonal Vectors – Gram Schmidt Orthogonalization Process – Orthogonal Complement – Least Square Approximations.

UNIT IV NUMERICAL SOLUTION OF LINEAR SYSTEM OF EQUATIONS 9+3

Solution of Linear System of Equations – Direct Methods: Gauss Elimination Method – Pivoting, Gauss Jordan Method, LU Decomposition Method and Cholesky Decomposition Method - Iterative Methods: Gauss-Jacobi Method, Gauss-Seidel Method and SOR Method.

UNIT V NUMERICAL SOLUTION OF EIGENVALUE PROBLEMS AND GENERALISED INVERSES 9+3

Eigen Value Problems: Power Method – Inverse Power Method – Jacobi's Rotation Method - QR Decomposition - Singular Value Decomposition Method.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

1. Linear independence/dependence of vectors
2. Computation of eigenvalues and eigenvectors
3. Diagonalization of Linear Transformation
4. Gram Schmidt Orthogonalization Process
5. Solution of algebraic and transcendental equations
6. Matrix Decomposition methods (LU / Cholesky Decomposition)

7. Iterative methods of Gauss-Jacobi and Gauss-Seidel
8. Matrix Inversion by Gauss-Jordan method
9. Eigen values of a matrix by Power method and by Jacobi's method
10. QR decomposition method
11. Singular Value Decomposition Method

OUTCOMES:

CO1: Solve system of linear equations using matrix operations and vector spaces using Algebraic methods.
CO2: Understand the linear maps between vector spaces and its utilities.
CO3: Apply the concept of inner product of spaces in solving problems.
CO4: Understand the common numerical methods and how they are used to obtain approximate solutions
CO5: Analyse and evaluate the accuracy of common numerical methods.

TEXT BOOKS:

1. Faires, J.D. and Burden, R., "Numerical Methods", Brooks/Cole (Thomson Publications), Fourth Edition, New Delhi, 2012.
2. Friedberg, S.H., Insel, A.J. and Spence, E., "Linear Algebra", Pearson Education, Fifth Edition, New Delhi, 2018.
3. Williams, G, "Linear Algebra with Applications", Jones & Bartlett Learning, First Indian Edition, New Delhi, 2019.

REFERENCES:

1. Bernard Kolman, David R. Hill, "Introductory Linear Algebra", Pearson Education, First Reprint, New Delhi, 2010.
2. Gerald, C.F, and Wheatley, P.O., "Applied Numerical Analysis", Pearson Education, Seventh Edition, New Delhi, 2004.
3. Kumaresan, S., "Linear Algebra – A geometric approach", Prentice – Hall of India, Reprint, New Delhi, 2010.
4. Richard Branson, "Matrix Operations", Schaum's outline series, Mc Graw Hill, New York, 1989.
5. Strang, G., "Linear Algebra and its applications", Cengage Learning, New Delhi, 2005.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

EI23301	ANALYSIS OF ELECTRIC CIRCUITS	L	T	P	C
		3	0	2	4

UNIT – I D.C and A.C CIRCUIT FUNDAMENTALS 9L, 3P

Linear, Nonlinear, Unilateral, Bilateral, Active and Passive elements - sources: - Ideal, Practical, Dependent and Independent. Laws: - Ohm's and Kirchhoff's Laws. Periodic waveforms: – Average, RMS values and Form factor- A.C quantities: - Current and Voltage relationship in R, L, and C circuits, Phasor representation - Impedance and admittance. Series and Parallel connections -Voltage and Current division. Y/Δ transformation. Power: - Real, Reactive, Apparent and Complex powers, Power factor.

PRACTICALS:

- Verification of Kirchhoff's voltage and Current laws

UNIT – II STEADY STATE ANALYSIS OF NETWORKS 9L, 6P

Analysis of simple RC, RL and RLC circuits and phasor diagrams. Network reduction: - Mesh and Nodal analysis of D.C and A.C circuits. Theorems for D.C and A.C networks: -Superposition, Thevenin's, Norton's, Maximum Power Transfer and Reciprocity.

PRACTICALS:

- Verification of Thevenin's and Norton's theorems.
- Verification of Superposition, Maximum Power transfer and Reciprocity theorems.

UNIT – III TRANSIENT ANALYSIS OF FIRST AND SECOND ORDER LINEAR CIRCUITS 9L, 3P

Source free RC, RL, RLC Circuit responses. Singularity functions. Step response of RC, RL, RLC series and parallel circuits. Responses of RC, RL and RLC series circuits to sinusoidal excitation.

PRACTICALS:

- Analysis of dc transients of RL, RC and RLC circuits for step input.

UNIT – IV RESONANCE AND COUPLED CIRCUITS 9L, 6P

Resonance in parallel and series circuits: –Half power frequencies, Bandwidth, Quality and Dissipation factor. Self and Mutual Inductance in coupled coils: - Dot convention, Coefficient of coupling. Sinusoidal steady state analysis of network with coupled inductance.

PRACTICALS:

- Analysis of the frequency response of Series and Parallel resonance circuits.
- Understanding coupled networks.

UNIT – V THREE PHASE CIRCUITS AND TWO PORT NETWORKS 9L, 12P

Three phase balanced and unbalanced voltage sources and loads: – Line and Phase voltages and currents, Phasor diagram, Analysis with star and delta balanced and unbalanced loads. Power and Power factor and their measurement. Two port networks: - Z-parameters, T-equivalent network, Y-parameter, π-equivalent network, h-parameters and g-parameters.

PRACTICALS:

- Analysis of balanced and unbalanced three phase circuits.
- Power and power factor measurement in three phase circuits by two wattmeter method.

- Determination of z and y parameters of a two-port network and verifying with equivalent T and π networks.
- Determination of h and g parameters of a two-port network.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

1. Comprehensive knowledge on fundamental principles and laws of dc and ac networks and ability to obtain and verify their characterizing equations. (L1,L2)

9. Ability to reduce complex network into simplified network using theorems and verify and analyse its performance. (L3)
10. Ability to determine, analyse and demonstrate the time & frequency responses of RL, RC and RLC circuits. (L4)
11. Ability to determine and verify circuit variables of inductively coupled and three phase networks. (L3)
12. Ability to determine analytically and experimentally various circuit parameters of two port networks systems. (L3)
13. Ability to use the software tools for addressing engineering problems involving large scale networks. (L3, L4)

REFERENCES:

1. Robert L. Boylsted, R.L., “Introductory Circuit Analysis”, Prentice Hall, 13th Edition, 2016.
2. Alexander, C.K., Matthew, N.O., and Sadiku, “Fundamentals of Electric Circuits”, McGraw-Hill, 2007.
3. Edminister, J.A. and Nahvi, M., “Electric Circuits”, Schaum’s Outline series, McGraw-Hill, 7th Edition, 2018.
4. HAYT, Jr.W. H., Kemmerly, J.E., and Durbin, S.M., “Engineering Circuit Analysis”, McGraw-Hill, 8th Edition, 2007.
5. Decarlo, R.A. and Lin, P.M., “Linear Circuit Analysis”, Oxford University Press, 2nd Edition, 2001.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	3	-	-	1	2	1	1	2	-	3	1
CO2	3	3	3	3	3	-	-	1	2	1	1	2	-	3	1
CO3	3	3	3	2	3	-	-	1	2	1	1	2	-	3	1
CO4	3	3	3	2	3	-	-	1	2	1	1	2	-	3	1
CO5	3	3	3	3	3	-	-	1	2	1	1	2	-	3	1
CO6	3	3	3	2	3	-	-	1	2	1	1	2	-	3	1
Avg	3	3	3	2.3	3	-	-	1	2	1	1	2	-	3	1

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23302 ELECTRONICS FOR ANALOG SIGNAL PROCESSING - I

L	T	P	C
3	0	2	4

UNIT – I SEMICONDUCTOR DIODES 9L, 9P

PN junction diode and its applications as Rectifier, Clipper and Clamper circuits - Zener diode and its application as voltage regulator – UJT and its application as relaxation oscillator.

PRACTICALS:

- Analysis of PN junction diode characteristics and construction of rectifier circuits
- Analysis of Zener diode characteristics and construction of voltage regulator circuits.
- Analysis of UJT characteristics and construction of relaxation oscillator circuit.

UNIT – II TRANSISTORS AND THYRISTORS 9L, 9P

BJT: NPN and PNP - CE, CB and CC configurations, h-parameters, Early effect, Thermal runaway. FET: N channel and P channel - JFET, EMOSFET, DMOSFET - CS, CG and CD configurations. SCR and its application as controlled rectifier - DIAC and TRIAC.

PRACTICALS:

- Analysis of BJT characteristics in CE configuration and determination of h-parameters.
- Analysis of JFET characteristics in CS configuration and determination of voltage amplification factor.
- Analysis of SCR characteristics and construction of controlled rectifier circuit.

UNIT – III TRANSISTOR AMPLIFIERS 9L, 6P

BJT and FET Biasing circuits – Small signal analysis and frequency response of CE and CS amplifiers - Coupling methods for cascading amplifiers - Darlington and Cascade amplifiers, Gain-Bandwidth product, Introduction to Tuned Amplifiers.

PRACTICALS:

- Design and verification of BJT and FET biasing circuits
- Analysis of frequency response for BJT and FET amplifiers

UNIT – IV FEEDBACK AMPLIFIERS AND OSCILLATORS 9L, 3P

Feedback amplifiers: Voltage-Series, Voltage-Shunt, Current-Series and Current-Shunt amplifier circuits. Oscillators: RC phase shift, Wien Bridge, Hartley and Colpitts oscillators.

PRACTICALS:

- Design and verification of Wien Bridge oscillator and Colpitts oscillator circuits.

UNIT – V DIFFERENTIAL AMPLIFIER AND OPAMP 9L, 6P

Differential amplifier: BJT configuration - Differential mode and common mode operations, CMRR. OPAMP: Functional block diagram – DC and AC characteristics – Inverting and Non-inverting amplifiers

PRACTICALS:

- Realization of inverting and non-inverting amplifier and its gain

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Select appropriate semiconductor devices for a given application. (L2, L3)
2. Explain the operation and characteristics of various types of BJTs and FETs. (L1, L2)
3. Construct biasing circuits for BJT and FET amplifiers and analyze the frequency response. (L3, L4)
4. Analyze the feedback amplifiers and design RC and LC oscillators. (L3, L4)
5. Develop analytical capability in the area of differential amplifiers and OPAMP. (L2, L3)
6. Solve complex problems and design suitable electronic circuits for the given specifications. (L5)
7. Construct various analog circuits using semiconductor devices with the help of hardware & software platforms and analyze the performance through experiments. (L3)
8. Design various voltage rectifiers, regulators, amplifiers and oscillators for given specifications and verify the performance through experiments. (L4)

REFERENCES:

1. Jacob Millman, Christos C. Halkias, SatyabrataJit, “Electronic Devices and Circuits”, McGraw Hill, 4th Edition, 2017.
2. Donald A. Neaman, “Electronic Circuits Analysis and Design”, Tata McGraw Hill, 3rd Edition, 2008.
3. Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson Education, 11th Edition, 2015.
4. Sedra and Smith, “Microelectronic circuits”, Oxford University Press, 7th Edition, 2014.
5. David A. Bell, “Electronic Devices and Circuits”, Oxford University Press, 5th Edition, 2008.
6. Ben G. Streetman and Sanjay K. Banerjee, “Solid State Electronic Devices”, 7th Edition,2015.
7. Donald A. Neaman, “Semiconductor Physics and Devices Basic Principles”, McGraw Hill, 3rd Edition, 2012.
8. NPTEL video lectures on “Electronics for Analog Signal Processing I” by Prof. K.R.K. Rao, IITM.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	2	1	3	1	-	1	1	2	-	2	-	2	-
CO2	3	3	3	2	3	1	-	1	1	2	-	2	-	2	-
CO3	3	2	2	1	3	-	-	1	1	2	-	2	-	2	-
CO4	3	2	2	2	3	1	-	1	1	2	-	2	-	2	-
CO5	3	2	2	1	3	-	-	1	1	2	-	2	-	2	-
CO6	3	2	2	-	3	1	-	1	1	2	-	2	-	2	-
CO7	3	2	2	-	3	1	-	1	1	2	-	2	-	2	-
CO8	3	2	3	2	3	1	-	1	1	2	-	2	-	2	-
Avg.	3	2.1	2.3	1.7	2.7	1	-	1	1	2	-	2	-	2	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23303	BASICS OF SIGNALS AND SYSTEMS	L	T	P	C
		3	0	2	4

UNIT – I INTRODUCTION TO CONTINUOUS TIME AND DISCRETE TIME SIGNALSANDSYSTEMS 9L, 6P

Definition of Continuous Time (CT) and Discrete Time (DT) signals, Representations and Classifications of deterministic signals. Random signal characteristics - Mean, Standard deviation, variance, autocorrelation, cross-correlation, Skewness and Kurtosis. Definition of CT and DT systems, Classifications and characterization, LTI systems.

PRACTICALS:

- Generation of standard CT and DT signals: Impulse, Step, Pulse, Sine, Exponential.
- Operations on signals: Addition, Multiplication, Convolution and Correlation.

UNIT – II ANALYSIS OF CONTINUOUS TIME AND DISCRETE TIME SIGNALS AND SYSTEMS IN TIME DOMAIN 9L, 6P

LTI system–Convolution–Properties of convolution-Continuous Time systems– Differential equations Discrete Time systems–Discrete convolution–Difference equations–Impulse response and step response of Continuous Time and Discrete Time systems– Recursive and Non recursive systems.

PRACTICALS:

- Response of CT-LTI system using convolution integral and differential equation.
- Response of DT-LTI system using convolution sum and difference equation.
- Statistical analysis of random signals.

UNIT – III TRANSFORM DOMAIN ANALYSIS OF CONTINUOUS TIME SIGNALS AND SYSTEMS 9L, 6P

Fourier Series representation of signals – Continuous Time Fourier Series (CTFS) – Fourier Transform – Continuous Time Fourier Transform (CTFT) – Definition, Existence and properties-Fourier Transform analysis of Continuous Time signals and systems–Laplace transform analysis of Continuous Time systems, Stability, Causality

PRACTICALS:

- Frequency response of CT-LTI system using LT and CTFT.
- Testing of CT-LTI systems for causality and stability using LT analysis.

UNIT – IV TRANSFORM DOMAIN ANALYSIS OF DT SIGNALS AND SYSTEMS 9L, 6P

Discrete Time Fourier Transform–Definition, Existence and Properties. Z Transform–Definition, Properties, ROC and its properties, Inverse Z Transform. Analysis of Discrete Time systems using Z Transforms, Stability, Causality.

PRACTICALS:

- Frequency response of DT-LTI system using ZT and DTFT.
- Testing of DT-LTI systems for causality and stability using ZT analysis.

UNIT – V DISCRETIZATION AND SIGNAL RECONSTRUCTION 9L, 6P

Discretization of signals: Sampling theorem, Frequency aliasing, Nyquist rate, Anti aliasing filter, Analog to Digital conversion, Quantization. Signal reconstruction, Digital to Analog conversion, Interpolation using zero-order hold and first order hold.

PRACTICALS:

- Verification of sampling theorem – Under sampling, critical sampling and over sampling.
- Quantization, ADC and DAC operations.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Characterize and classify CT and DT signals and systems. (L3)
2. Obtain the response of LTI systems using time-domain analysis methods. (L2)
3. Analyze CT signals and systems in Transform Domain using Fourier and Laplace Transforms. (L3)
4. Analyze the DT signals and systems using Fourier and Z Transforms. (L3)
5. Select the sampling frequency and quantization levels for given specifications. (L4)
6. Solve problems in the analysis of CT and DT signals and systems. (L4)
7. Construct CT and DT signals and analyze their characteristics using simulation tools. (L2)
8. Analyze CT and DT LTI systems in time and frequency domain using simulation tools. (L3)

REFERENCES:

1. AllanV. Oppenheim, S.Wilskyand S.H.Nawab, "Signals and Systems", Pearson Education, Indian Reprint, 2007.
2. ArunK Tangirala, Principles of System Identification, CRC press 2017.
3. Tarun Kumar Rawat, Signals and Systems, Oxford University Press, 2010.
4. Edward W Kamen, Bonnie S Heck, Fundamentals of Signals and Systems using the Web and MATLAB, Pearson Education, Indian Reprint, 2013.
5. H. P. Hsu, Signals and Systems, Schaum's Outlines, Tata McGraw Hill, 2006.
6. Nptel video lectures on "Signals and Systems" by Prof. S.C. Dutta Roy, IIT Delhi, https://www.youtube.com/playlist?list=PLC6210462711083C4.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	-	1	1	-	-	-	-	-	-	1	-	-	-
CO2	2	2	-	1	1	1	-	-	-	-	-	1	3	-	-
CO3	3	2	-	1	3	-	-	-	-	-	-	2	-	3	-
CO4	2	3	-	2	2	-	-	-	-	-	-	1	-	-	-
CO5	2	2	1	2	2	-	1	-	-	-	-	1	-	-	1
CO6	3	3	3	3	3	2	-	-	-	-	-	3	3	3	1
CO7	3	3	3	2	3	2	1	1	3	2	1	2	3	3	1
CO8	3	3	3	2	3	2	1	1	3	2	1	2	3	3	1
Avg.	2.6	2.6	2.5	1.8	2.3	1.8	1	1	3	2	1	1.6	3	3	1

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23304	ELECTRICAL MACHINES	L	T	P	C
		3	0	2	4

UNIT – I DC MACHINES 9L, 6P

Construction of D.C. Machines – DC Generator: Principle of operation -EMF equation -Characteristics –Introduction to Commutation process and Armature reaction DC Motor: Principle of operation -Types-Torque Equation-Characteristics - Starters - Speed Control-Applications of DC machines.

PRACTICALS:

- Determination of open circuit and load characteristics of self excited DC generator.
- Speed control of DC shunt motor by manipulating field and armature parameters.
- Determining the load characteristics of DC shunt motor using PC based data acquisition system.

UNIT – II TRANSFORMERS 9L, 6P

Transformer - Principle - Theory of ideal transformer - EMF equation - Construction details of shell and core type transformers - Tests on transformers - Equivalent circuit – Phasor diagram on load-Regulation and efficiency of a transformer.

PRACTICALS:

- Predetermination of efficiency and regulation of single-phase transformer.
- Load test on single phase transformer.

UNIT – III THREEPHASE INDUCTION MOTOR 9L, 3P

Three phase Induction motor: -Types, Construction and principle of operation - torque and toque-slip characteristics- Efficiency- Application- Starting methods – speed control of induction motor.

PRACTICALS:

- Load test on three phase induction motor.

UNIT – IV SYNCHRONOUS MACHINES 9L, 6P

Alternators: Principle of operation, Construction details - induced EMF equation - Vector Diagram Voltage regulation - Synchronous motor: Principle of operation, Starting methods - Torque –V curves, Hunting.

PRACTICALS:

- V curves of synchronous motor for different load conditions.
- PC based monitoring and regulation of three- phase alternator.

UNIT – V SPECIAL MACHINES 9L, 6P

Single phase Induction motor – Torque Development– Capacitor start capacitor run motors – Shaded pole motor, Universal motor, Permanent magnet synchronous motor, Brushless DC motor, Introduction to stepping motors, Switched reluctance motor.

PRACTICALS:

- Load test on single phase induction motor.
- Study of AC and DC drives.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Understand the underlying concept, working principle and characteristics of dc machines, solve problems related to selection and performance and demonstrate the concept of no load and full load test on dc machine. (L1, L2)
2. Classify, understand the working principles and characteristics of transformers, analyse and demonstrate their performance. (L1, L4)
3. Classify, understand the operating principle and analyse the performance of three phase induction motor and demonstrate its efficiency and regulation. (L1, L2)
4. Classify, understand the working principle and analyse the performance characteristics of three phase synchronous machines by acquiring electrical parameters using suitable software. (L1, L2)
5. Apply the knowledge on various machines to choose appropriate machines for specific application and to solve complex engineering problems. (L1, L2)
6. Understand the working principle of special type of machines and choose their applications. (L1, L2)

REFERENCES:

1. Fitzgerald A.E., Kingsley C., Umans, S. and Umans S.D., "Electric Machinery", McGraw-Hill, 6th Edition, 2003
2. Kothari, D.P., I.J. Nagrath, I.J., "Electric Machines", McGraw Hill Education, 5th Edition, 2017.
3. Theraja, B.L., Theraja, A.K.,"A Text book of Electrical Technology Vol.II AC & DC Machines", S.C Chand and Co Ltd., 23rd Edition, 2007.
4. Stephen Chapman, "Electric Machinery Fundamentals", McGraw Hill Education, 4th Edition, 2017.
5. Del Toro, V., "Electrical Engineering Fundamentals", Pearson Education India, 2nd Edition, 2015.
6. Ashfaq Husain and Harroon Ashfaq, "Electric Machines", Dhanpat Rai & Co., 3rd Edition, 2016.
7. Janardanan, E.G., "Special Electrical Machines", Prentice Hall India, 2014.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	3	-	-	1	1	2	1	1	3	2	1
CO2	3	3	3	2	3	-	-	1	1	2	1	1	3	2	1
CO3	3	3	3	2	3	-	-	1	1	2	1	1	3	2	1
CO4	3	3	3	2	3	-	-	1	1	2	1	1	3	2	1
CO5	3	3	3	2	3	-	-	1	1	2	1	1	3	2	2
CO6	3	3	3	2	3	-	-	1	1	2	1	2	3	2	2
Avg	3	3	3	2	3	-	-	1	1	2	1	1.2	3	2	1.3

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23S01	SIMULATION TOOLS FOR INSTRUMENTATION ENGINEERING	L	T	P	C
		1	0	2	2

UNIT – I ARITHMETIC OPERATIONS 3L, 6P

Basic arithmetic operations - Software interface and basic commands - Variables and workspace, arrays and matrices - Arithmetic operations - Matrix operation.

PRACTICALS:

- Hands-on practice with software packages and basic commands.
- Simple arithmetic and matrix operation exercises.

UNIT – II PROGRAMMING CONSTRUCTS 3L, 6P

Creating and running scripts - Function creation, input/output arguments - Conditional statements (If/else) - For loop - While loop - Block diagram programming - Common errors.

PRACTICALS:

- Writing and executing functions.
- Implementing conditional statements and loops.

UNIT – III DATA VISUALIZATION AND PLOTTING 3L, 6P

2D plots: plot, scatter, bar - Formatting plots: titles, labels, legends, annotations - Subplots - Data interpolation and fitting - Visualizing real-world data.

PRACTICALS:

- Creating and customizing different types of plots.
- Visualizing real world data sets.

UNIT – IV SOLVING EQUATIONS 3L, 6P

Solving linear systems - Numerical Integration and Differentiation - Solving ordinary differential equations.

PRACTICALS:

- Implementing numerical methods.

UNIT – V APPLICATIONS TO INSTRUMENTATION ENGINEERING 3L, 6P

Synthesis of common input signals (Impulse input, step input, Ramp input, Sinusoidal input) - Obtaining input/output response from simple systems.

PRACTICALS:

- Synthesis of common input signals such as Impulse input, step input, Ramp input and Sinusoidal input.
- Obtaining input/output data from simple systems.

TOTAL: 15L + 30P = 45 PERIODS

COURSE OUTCOMES:

After completing the above subject, students will have.

1. Perform Basic Arithmetic and Matrix Operations. (L1)
2. Develop and Execute Programs Using Fundamental Programming Constructs. (L2)
3. Create and Customize Data Visualizations. (L2)
4. Solve Mathematical Problems Using Numerical Methods. (L3)
5. Synthesize and Analyze Input Signals for Instrumentation Engineering. (L4)
6. Apply Software Tools to Real-World Engineering Problems. (L6)

REFERENCES:

1. Gilat, A. (2004). MATLAB: An introduction with Applications. John Wiley & Sons.
2. Lindfield, G., & Penny, J., “Numerical methods: using MATLAB”, Academic Press, 2018.
3. Dukkipati, R. V., “MATLAB: an introduction with applications”, New Age International, 2008.
4. Kuhlman, D., “A python book: Beginning python, advanced python, and python exercises”, (pp. 1-227), Lutz: Dave Kuhlman, 2009.
5. Mastrodomenico, R., “The python book”, John Wiley & Sons, 2022.
6. Campbell, S. L., Chancelier, J. P., Nikoukhah, R., Campbell, S. L., Chancelier, J. P., & Nikoukhah, R., “Modeling and Simulation in SCILAB) (pp. 73-106), Springer New York, 2010.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO3	-	3	3	2	3	-	2	-	-	-	-	-	3	-	-
CO4	-	2	3	3	-	2	2	-	2	-	2	2	3	-	-
CO5	-	2	3	3	-	2	2	-	2	2	2	2	3	-	-
CO6	-	3	3	3	-	2	2	2	2	2	2	2	3	-	-
Avg.	3	2.3	3	2.8	3	2	2	2	2	2	2	2	3	-	-

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23U01 **STANDARDS – E & I** **L T P C**

1 0 0 1

MODULE I – OVERVIEW OF STANDARDS **6**

Basic concepts of standardization; Purpose of Standardization, marking and certification of articles and processes; Importance of standards to industry, policy makers, trade, sustainability and innovation. Objectives, roles and functions of BIS, Bureau of Indian Standards Act, ISO/IEC Directives; WTO Good Practices for Standardization. Important Indian and International Standards.

MODULE Ii **ELECTRICAL SAFETY** **15 L**

Graphical Symbols For Diagrams, Letter Symbols And Signs, - Units And Systems Of Measurement - Standard Values - Protection Against Electric Shock - Protection Against Thermal Effects And Protection Against Fire Due To Arcing - Protection For Safety Protection Against Overcurrent And Fault Currents - Measures Against Electromagnetic Influences - Electrical Installations In Industrial Buildings: Wiring And Earthing Systems - Electrical Installations In Hazardous Areas: Classification Of Hazardous Areas, Guidelines For Electrical Installations

TOTAL: 15L = 45 PERIODS

COURSE OUTCOMES:

After completing the above subject, students will have.

1. Understand the standards related to graphical symbols, letter symbols, signs, units, and systems of measurement in electrical diagrams and installations. (L1)
2. Identify protection measures against electric shock, thermal effects, and fire due to arcing, ensuring electrical safety in various installations. (L2)
3. Understand standards for protection against overcurrent, fault currents, and electromagnetic influences in electrical systems. (L3)
4. Understand the standards for safe electrical installations in industrial buildings, including appropriate wiring and earthing systems. (L2)
5. Classify hazardous areas and follow guidelines for electrical installations in these areas to ensure safety. (L3)

REFERENCES:

1. National Electrical Code of India, “Bureau of Indian Standards”, Second Revision, 2023.
2. Sutherland, P. E., “Principles of electrical safety”, John Wiley & Sons, 2014.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	-	-	-	-	3	3	3	-	-	-	3	-	-	-
CO2	2	-	-	-	-	3	3	3	-	-	-	3	-	-	-
CO3	2	-	-	-	-	3	3	3	-	-	-	3	-	-	-
CO4	2	-	-	-	-	3	3	3	-	-	-	3	-	-	-
CO5	2	-	-	-	-	3	3	3	-	-	-	3	-	-	-
CO6	2	-	-	-	-	3	3	3	-	-	-	3	-	-	-
Avg.	2	-	-	-	-	3	3	3	-	-	-	3	-	-	-

1-Low, 2-Medium, 3-High, ‘-“- no correlation

UC23U01 **UNIVERSAL HUMAN VALUES** **L T P C**
1 0 2 2

COURSE OBJECTIVE:

The objective of the course is four-fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

MODULE I: INTRODUCTION **(3L,6P)**

Purpose and motivation for the course, recapitulation from Universal Human Values-I, Self-Exploration– Its content and process; 'Natural acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Practical Session: *Include sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking*

MODULE II: HARMONY IN THE HUMAN BEING **(3L,6P)**

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - happiness and physical facility, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Health.

Practical Session: *Include sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.*

MODULE III: HARMONY IN THE FAMILY AND SOCIETY **(3L,6P)**

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship, Understanding the meaning of Trust; Difference between intention and competence, Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals, Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Practical Session*: Include sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives*

MODULE IV: HARMONY IN THE NATURE AND EXISTENCE (3L,6P)

Understanding the harmony in the Nature, Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self regulation in nature, Understanding Existence as Co-existence of mutually interacting units in all- pervasive space, Holistic perception of harmony at all levels of existence.

Practical Session: *Include sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.*

MODULE V: IMPLICATIONS OF HARMONY ON PROFESSIONAL ETHICS (3L,6P)

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations, Sum up.

Practical Session: *Include Exercises and Case Studies will be taken up in Sessions E.g. To discuss the conduct as an engineer or scientist etc.*

TOTAL: 45 (15 Lectures + 30 Practicals) PERIODS

COURSE OUTCOME:

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

1. Become more aware of themselves, and their surroundings (family, society, nature);
2. Have more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
3. Have better critical ability.
4. Become sensitive to their commitment towards what they have understood (human values, human relationship and human society).
5. Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

REFERENCES:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 3rd revised edition, 2023.
2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4. The Story of Stuff (Book).
5. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6. Small is Beautiful - E. F Schumacher.
7. Slow is Beautiful - Cecile Andrews.
8. Economy of Permanence - J C Kumarappa
9. Bharat Mein Angreji Raj - PanditSunderlal

10. Rediscovering India - by Dharampal
11. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. India Wins Freedom - Maulana Abdul Kalam Azad
13. Vivekananda - Romain Rolland (English)
14. Gandhi - Romain Rolland (English)

Web URLs:

1. Class preparations: https://fdp-si.aicte-india.org/UHV-II%20Class%20Note.php
2. Lecture presentations: https://fdp-si.aicte-india.org/UHV-II_Lectures_PPTs.php
3. Practice and Tutorial Sessions: https://fdp-si.aicte-india.org/UHV-II%20Practice%20Sessions.php

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1	1	1	3			3
CO2						1	1	1	3			3
CO3						3	3	2	3		1	3
CO4						3	3	2	3		1	3
CO5						3	3	3	3		2	3

MA23C05 **PROBABILITY AND STATISTICS**

L	T	P	C
3	1	0	4

UNIT – I ONE-DIMENSIONAL RANDOM VARIABLES 9L, 3T

Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Functions of a random variable.

UNIT – II TWO-DIMENSIONAL RANDOM VARIABLES 9L, 3T

Creating and running scripts - Function creation, input/output arguments - Conditional statements (If/else) - For loop - While loop - Block diagram programming - Common errors.

UNIT – III ESTIMATION THEORY 9L, 3T

Sampling distributions – Characteristics of good estimators – Method of Moments – Maximum Likelihood Estimation – Interval estimates for mean, variance and proportions.

UNIT – IV TESTS OF SIGNIFICANCE 9L, 3T

Type I and Type II errors – Tests for single mean, proportion, Difference of means (large and small samples) – Tests for single variance and equality of variances – test for goodness of fit – Independence of attributes.

UNIT – V VDESIGN OF EXPERIMENTS 9L, 3T

Completely Randomized Design – Randomized Block Design – Latin Square Design – 22 factorial design.

TOTAL: 45L + 15P = 60 PERIODS

COURSE OUTCOMES:

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

1. To analyze the performance in terms of probabilities and distributions achieved by the determined solutions.
2. To be familiar with some of the commonly encountered two dimensional random variables and be equipped for a possible extension to multivariate analysis.
3. To apply the basic principles of the estimation theory to practical situations.
4. To demonstrate the knowledge of large / small sample theory in statistical inference.
5. To obtain a better understanding of the importance of the methods in modern industrial processes.

REFERENCES:

1. Irwin Miller and Marylees Miller "John E. Freund's Mathematical Statistics with applications", Pearson India Education, Asia, 8th Edition, 2014.
2. Devore, J.L. "Probability and Statistics for Engineering and the Sciences", Cengage Learning, 8th Edition, 2011.
3. Milton, J.S. and Arnold, J.C. "Introduction to Probability and Statistics", Tata McGraw Hill, New Delhi, 4th Edition, 3rd Reprint, 2008.
4. Ross, S.M. "Introduction to Probability and Statistics for Engineers and Scientists", Elsevier, New Delhi, 5th Edition, 2014.
5. Spiegel, M.R., Schiller, J., Srinivasan, R.A. and Goswami, D. "Schaum's Outline of Theory and Problems for Probability and Statistics", McGraw Hill Education, 3rd Edition, Reprint, 2017.
6. Walpole, R.E., Myers R.H., Myres S.L., and Ye, K. "Probability and Statistics for Engineers and Scientists", Pearson Education, Asia, 9th Edition, 2011.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	3	2	-	-	-	-	-	-	3	3	-	-
CO2	3	3	2	3	2	-	-	-	-	-	-	3	3	-	-
CO3	3	3	2	3	2	-	-	-	-	-	-	3	3	-	-
CO4	3	3	2	3	2	-	-	-	-	-	-	3	3	-	-
CO5	3	3	2	3	2	-	-	-	-	-	-	3	3	-	-
Avg.	3	3	2	3	2							3	3		

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23401 ELECTRONICS FOR ANALOG SIGNAL PROCESSING – II

L	T	P	C
3	0	2	4

UNIT – I FABRICATION OF INTEGRATED CIRCUITS 9L, 6P

Silicon wafer preparation – Epitaxial growth – Photolithography – Process steps – Implantation – Etching – Metallization – Packaging – Fabrication of passive and active devices in IC. OPAMP – Review of Inverting and Non-Inverting configurations.

PRACTICALS:

- Implementation of OPAMP Inverting and Non-inverting amplifier based circuits (Scale changer, Adder, Subtractor, etc).
- Familiarization of Electronic Devices and Circuits (EDC) simulation tools.

UNIT – II APPLICATIONS OF OPAMP 9L, 6P

Summing and Difference amplifiers, Differentiator and Integrator: ideal and practical circuits, V to I and I to V converters - Clipper and Clamper – Log and Antilog amplifiers, Precision Rectifier, Instrumentation amplifier circuit analysis, Instrumentation amplifier IC – Active Filters: Low pass, High pass, Band pass and Band reject filters – Comparator, Schmitt trigger, Multi-vibrators, Triangular wave generator, Sine wave generator.

PRACTICALS:

- Design and implementation of V to I converter and I to V converter using Opamp.
- Realization of PID controller using OPAMP.
- Design and implementation of active filters using Opamp.
- Design and implementation of waveform generators (sine, triangular and rectangular)

UNIT – III TIMER AND PHASE LOCKED LOOP 9L, 6P

Timer IC: Internal blocks – Multivibrator circuits and their applications. VCO: Functional block diagram, Operation, V-F conversion factor, Application – Phase detector: Analog and Digital, Conversion gain – PLL IC: Internal block diagram, Operation, Capture range, Lock range, Applications: Generation of FM signal, Demodulation of AM, FM and FSK signals.

PRACTICALS:

- Applications of Timer IC (Astable and Monostable Multivibrators).
- Design and implementation of V-to-F converter (VCO).

UNIT – IV ADC AND DAC 9L, 6P

Analog switches, Sample and hold IC, DAC principle, Resolution, Range – Types: Weighted R, R2R and Inverted R-2R, DAC ICs – ADC: Principle, Types: Flash, sigma-delta convertors Single slope, Dual slope, Successive approximation – ADC ICs.

PRACTICALS:

- Implementation of ADC using OPAMP.
- Implementation of DAC circuits.
- Study of ADC and DAC ICs.

UNIT – V SPECIAL FUNCTION IC'S 9L, 6P

Analog multiplier: Single, double and four quadrant multipliers - Operational trans-conductance amplifier, Audio amplifier – Linear voltage regulator: Internal blocks, low and high voltage regulator operation, Current protection – Switched regulator, Buck, Boost & Buck/boost regulators – Switched capacitor filter, Isolation amplifier, Opto-coupler.

PRACTICALS:

- Design and implementation of Linear Voltage Regulator.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Explain the fabrication process of ICs and OPAMP characteristics.
2. Design OPAMP based circuits for given specifications. (L2, L3, L4)
3. Design circuits using Timer IC and PLL IC. (L3, L4)
4. Select appropriate ADC and DAC IC's for chosen applications. (L4, L5)
5. Design linear voltage regulator circuits. (L3, L4)
6. Solve complex problems and design suitable integrated circuits for given specifications. (L5)
7. Construct various integrated circuit applications using hardware & software platforms and analyze the performance through experiments. (L3,L4,L5)
8. Design IC based application for a given analog signal processing application and verify the performance through experiments. (L3, L4, L5)

REFERENCES:

1. Jacob Millman, Christos C. Halkias, SatyabrataJit, "Electronic Devices and Circuits", McGraw Hill, 4th Edition, 2017.
2. Roy Choudury, D., and Shail B. Jain, "Linear Integrated Circuits", New Age International, 4th Edition, 2011.
3. Ramakant Gayakwad, "Op-amps and Linear Integrated Circuits", Pearson, 4th Edition, 2015.
4. Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers and Linear Integrated Circuits", Prentice Hall, 6th Edition, 2001.
5. Paul R. Gray, "Analysis and Design of Analog Integrated Circuits", Wiley, 5th Edition, 2010.
6. Sergio Franco, "Design with Operational Amplifiers and Linear Integrated Circuits", Tata McGraw Hill, 3rd Edition, 2016.
7. NPTEL video lectures on "Electronics for Analog Signal Processing II" by Prof. K.R.K. Rao, IITM.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	2	1	1	2	2	2	3	3	-	2	-
CO2	3	3	3	3	2	1	1	2	2	2	3	3	-	2	-
CO3	3	3	3	3	3	1	1	2	2	2	3	3	-	2	-
CO4	3	3	3	3	3	1	1	2	2	2	3	3	-	2	-
CO5	3	3	2	2	3	1	1	2	2	2	3	3	-	2	-
CO6	3	3	3	3	3	1	1	2	2	2	3	3	-	2	-
CO7	3	3	2	2	3	1	1	2	2	2	3	3	-	2	-
CO8	3	3	3	3	3	1	1	2	2	2	3	3	-	2	-
Avg.	3	3	2	2	3	1	1	2	2	2	3	3	-	2	-

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23402	DIGITAL SYSTEMS	L	T	P	C
		3	0	2	4

UNIT – I BOOLEAN ALGEBRA AND LOGIC GATES 9L, 6P

Review of number systems – Arithmetic operations in binary number system – Binary codes – Boolean algebra and rules – Boolean functions: Simplifications: standard / canonical form of SOP and POS, Simplification using Karnaugh Map and Tabulation methods – Basic logic gates – Universal gates. Logic Families &their characteristics – DTL, TTL, CMOS, FAN-IN, FAN-OUT.

PRACTICALS:

- Verification of logic gates.
- Realization of Boolean expressions using logic gates.
- Familiarization of simulation tools for Digital Logic Design.

UNIT – II COMBINATIONAL LOGIC 9L, 6P

Combinational circuits – Analysis and design procedures – Circuits for arithmetic operations: Full adder, Carry look-ahead adder, binary adder, adder-subtractor, comparators – Code conversion – Decoders and Encoders – Multiplexers and De-multiplexers. Realization of combinational logic circuits using decoders and multiplexers.

PRACTICALS:

- Implementation of Combinational logic circuits using MUX and Decoder ICs.
- Design of code converters, Encoder and Decoder using logic gates.

UNIT – III SYNCHRONOUS SEQUENTIAL LOGIC 9L, 6P

Sequential circuits – Flip flops: Triggering, types, conversions, excitation tables – Analysis and design procedures – State reduction and state assignment – Shift registers – Counters: MOD counters, up-down counter, ring counters – Sequence detectors.

PRACTICALS:

- Verification of flip-flops.
- Implementation of universal shift registers.
- Design and implementation of Synchronous Counters using flip-flops.

UNIT – IV ASYNCHRONOUS SEQUENTIAL LOGIC 9L, 6P

Analysis and design of asynchronous sequential circuits – Reduction of state and flow tables – Race-free state assignment – Arithmetic State Machines: Introduction, components, features, examples

PRACTICALS:.

- Design and implementation of asynchronous sequential circuits using flip-flops.

UNIT – V MEMORY AND PROGRAMMABLE LOGIC DEVICES 9L, 6P

RAM and ROM types – Memory decoding - Error detection and correction - Programmable logic devices: Programmable Array Logic – Programmable Logic Array –CPLD - FPGA – Hardware Description Language: Introduction - HDL for combinational logic circuits - HDL for Sequential logic circuits.

PRACTICALS:

- Simulation of combinational/sequential logic circuits using HDL.
- Hardware realization of combinational/sequential logic circuits using FPGA/CPLD.
- Design and implementation of combinational / sequential logic circuit for instrumentation application such as Alarm / Interlock.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Apply mathematical knowledge of number systems, Boolean expressions / functions to simplify and realize logical expression, understand and contrast different logic families. (L3)
2. Analyze combinational and sequential (synchronous and asynchronous) logic circuits. (L4)
3. Construct combinational and sequential (synchronous and asynchronous) logic circuits. (L3)
4. Understand memory types and gain knowledge on building blocks of different Programmable Logic devices. (L1, L2)
5. Solve engineering problems in the area of digital logic circuit. (L3)
6. Make use of appropriate software such as VHDL/Verilog for electronic prototyping and modeling of digital system. (L3)
7. Design, implement and demonstrate sequential and combinational logic circuits for instrumentation applications. (L5)

REFERENCES:

1. Thomas L. Floyd, “Digital Fundamentals”, Prentice Hall, 11th Edition, 2015.
2. Donald P Leach, Albert Paul Malvino and GoutamSaha, “Digital Principles and Applications”, McGraw-Hill, 8th Edition, 2014.
3. Morris Mano, M. and Michael D. Ciletti, “Digital Design with an Introduction to the Verilog HDL”, Prentice Hall, 5th Edition, 2013.
4. Fundamentals of Logic Design, “Charles H Roth and Larry L KInney”, Cengage Learning, 6th Edition, 2013.
5. John F. Wakerly, “Digital Design Principles and Practices”, Pearson Education, 2008.
6. NPTEL video lectures on “Digital systems Design”, Prof. D. Roychoudhury IIT Kharagpur.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	2	1	1	2	2	2	3	3	-	2	-
CO2	3	3	3	3	2	1	1	2	2	2	3	3	-	2	-
CO3	3	3	3	3	3	1	1	2	2	2	3	3	-	2	-
CO4	3	3	3	3	3	1	1	2	2	2	3	3	-	2	-
CO5	3	3	2	2	3	1	1	2	2	2	3	3	-	2	-
CO6	3	3	3	3	3	1	1	2	2	2	3	3	-	2	-
CO7	3	3	3	3	3	1	1	2	2	2	3	3	-	2	-
Avg	3	3	2.7	2.7	2.7	1	1	2	2	2	3	3	-	2	-

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23403 **INSTRUMENT TRANSDUCERS**

L	T	P	C
3	0	2	4

UNIT – I MEASUREMENT PRINCIPLES AND TRANSDUCER CHARACTERISTICS **9L, 9P**

Units and standards – Classification of errors, Limiting and probable error – Error analysis –- Statistical methods – Odds and uncertainty – Error propagation – Classification of transducers – Static characteristics: Accuracy, precision, resolution, sensitivity, linearity, Rangeability – Dynamic characteristics – Modeling of transducers – Zero, first and second order transducers – Response to impulse, step, ramp and sinusoidal inputs.

PRACTICALS:

- Familiarization of PC based Data Acquisition for AI/AO and DI/DO using DAQ card.
- Determination of Static and Dynamic characteristics of transducer (RTD) using PC based Data Acquisition.

UNIT – II VARIABLE RESISTANCE TRANSDUCERS **9L, 12P**

Principle of operation, construction details, characteristics and applications of potentiometer, strain gauge, resistance thermometer, Thermistor, hot-wire anemometer, piezo-resistive sensor and humidity sensor.

PRACTICALS:

- Sensitivity analysis of strain gauge bridges (quarter, half and full) using PC based Data Acquisition.
- Determination of Static and Dynamic characteristics of Thermocouple (J / K / E) using PC based Data Acquisition.
- Design and implementation of Signal conditioning circuit for Load Cell.
- Determination of Static characteristics of Load Cell using PC based Data Acquisition.

UNIT – III VARIABLE INDUCTANCE AND VARIABLE CAPACITANCE TRANSDUCERS **9L, 3P**

Inductive transducers: Construction, principle, characteristics and signal conditioning of LVDT, Induction potentiometer – Variable reluctance transducers – Proximity sensor. Capacitive transducers: Principle, characteristics and signal conditioning – Applications: Capacitor microphone, Capacitive pressure sensor, Proximity sensor.

PRACTICALS:

- Static characteristics of linear displacement transducers (LVDT / Hall Effect sensor).

UNIT – IV OTHER TRANSDUCERS **9L, 6P**

Flapper-nozzle system Piezoelectric transducer – Hall Effect transducer – Magneto elastic sensor – Digital transducers – Fiber optic sensors – Seismic pickup transducers – Introduction to Smart transducers and its interface standard (IEEE 1451)

PRACTICALS:

- Static characteristics of flapper-nozzle system.

- Experimental study of seismic type accelerometer.

UNIT – V MEMS / NEMS 9L

Overview of Nano and Micro electromechanical Systems - MEMS force sensors - Micromachined accelerometers - Micromachined gyroscopes - MEMS pressure sensing techniques (micromachined silicon diaphragms, piezoresistive pressure sensors, capacitive pressure sensors, resonant pressure sensors) - Microfluidics and micro flow sensors.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Apply the Mathematical knowledge, basics of Science and Engineering fundamentals to solve the problems pertaining to measurement applications and to perform error analysis and uncertainty analysis. (L3)
2. Infer the static and dynamic characteristics of various transducers. (L2)
3. Explain different transduction principles of resistive, capacitive and inductive transducers. (L2)
4. Select and use the most appropriate transducer for a given application. (L4)
5. Design signal conditioning circuits for resistive, inductive and capacitive transducers. (L4)
6. Interpret the principle of non-conventional transducers and their applications. (L2)

REFERENCES:

1. Doebelin E.O. and Manik D.N., “Measurement Systems”, Tata McGraw Hill Education Pvt. Ltd., 6th Edition, 2011.
2. Renganathan, S., "Transducer Engineering”, Allied Publishes, 2003.
3. Murthy, D.V.S., “Transducers and Instrumentation”, Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, 2011.
4. Beeby, S., “MEMS mechanical sensors”, Artech House, 2004.
5. Neubert H.K.P., “Instrument Transducers – An Introduction to their Performance and Design”, Oxford University Press, Cambridge, 2005.
6. Albert D. Helfrick and Cooper, W. D., “Modern Electronic Instrumentation and Measurement Techniques”, PHI Learning Pvt. Ltd., 2017.
7. John P. Bentley, “Principles of Measurement Systems”, Pearson Education, 4th Edition, 2004
8. Bolton, W., “Engineering Science”, Elsevier Newnes, 2nd Edition, 1994.
9. Patranabis, D., “Sensors and Transducers”, Prentice Hall of India, 2nd Edition, 2003.
10. Choudhary, V., & Iniewski, K. (Eds.)., “Mems: Fundamental Technology and Applications”, CRC Press, 2017.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	2	1	-	-	-	1	-	-	-	-	3	-	-
CO2	3	2	2	1	-	-	-	1	-	-	-	-	3	-	-
CO3	3	2	2	1	-	-	-	1	-	-	-	-	3	-	-
CO4	3	2	2	1	-	-	-	1	-	-	-	-	3	-	-
CO5	3	2	3	-	-	-	-	1	-	-	-	-	3	3	-
CO6	3	2	1	-	-	-	-	1	-	-	-	-	3	-	-
Avg.	3	2	2	1	-	-	-	1	-	-	-	-	3	3	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23404	ELECTRICAL AND ELECTRONICS MEASUREMENTS	L	T	P	C
		3	0	2	4

UNIT – I MEASUREMENT OF ELECTRICAL PARAMETERS 9L, 9P

Types of ammeters and voltmeters: PMMC Instruments, Moving Iron Instruments, Dynamometer type Instruments – Resistance measurement: Wheatstone bridge, Kelvin double bridge and Direct deflection methods, Megger. Measurement of Inductance: Maxwell-Wein Bridge, Hay's bridge and Anderson Bridge - Measurement of Capacitance: Schering Bridge.

PRACTICALS:

- Calibration and testing of MI and MC Instruments.
- Measurement of resistance using Kelvin's Double bridge and inductance using Anderson bridge.
- Measurement of Capacitance using Schering's bridge.

UNIT – II POWER AND ENERGY MEASUREMENTS 9L, 6P

Electro-dynamic type wattmeter: Theory and its errors – LPF wattmeter – Phantom loading – Single phase Induction type energy meter: Theory and Adjustments – 3 phase induction energy meter and phase measurement (Synchroscope), –Calibration of wattmeter and Energy meters-smart energy meters

PRACTICALS:

- Calibration of Wattmeter.
- Calibration of single-phase energy meter.

UNIT – III POTENTIOMETERS AND INSTRUMENT TRANSFORMERS 9L, 6P

D.C. Potentiometers: Student type potentiometer, Precision potentiometer – A.C. Potentiometers: Polar and Coordinate types – Applications – Instrument Transformer: Construction and theory of Current Transformers and Potential Transformers.

PRACTICALS:

- Study of Instrument Transformers.

UNIT – IV ANALOG AND DIGITAL INSTRUMENTS 9L, 6P

Wave analyzers, Logic analyser, spectrum analyser – Signal and function generators – Distortion factor meter – Q meter – Digital voltmeter and multi-meter – Microprocessor based DMM with auto ranging and self-diagnostic features – Frequency & time period measurement, digital LCR meter

PRACTICALS:

- Simulation of microprocessor based DMM
- Study of Digital LCR Meter and Study of spectrum analyzer.

UNIT – V DISPLAY AND RECORDING DEVICES 9L, 6P

Cathode ray oscilloscope: Classification, Sampling–DSO, seven segment, Organic Light Emitting Diode display, LCD–Digital Data Recording –Digital memory waveform recorder – Data loggers, IOT enabled recorder.

PRACTICALS:

- Study of CRO and Digital storage oscilloscope.
- Study of IoT enabled data logger.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Understand and compare the working principles, merits, demerits, errors and calibrate different types of electrical measuring instruments. (L1, L2)
2. Select appropriate bridge networks for the measurement of resistance, capacitance and inductance. (L3)
3. Choose various electronic instruments for measurement of electrical quantities. (L3)
4. Illustrate the principles and practices of instrument design and development. (L2)
5. Apply various types of display and recording devices. (L3)
6. Justify appropriate instrument for typical measurements. (L5)

REFERENCES:

1. E.W. Golding & F.C. Widdis, “Electrical Measurements and Measuring Instruments”, Reem Publications Pvt, Ltd, 3rd Edition, 2011.
2. Albert D Helfrick, William D cooper, “Modern Electronic Instrumentation & Measurement Techniques”, Pearson India Education, 2015.
3. David. A. Bell, Electronic Instrumentation and Measurements, Oxford University Press, 3rd Edition, 2013.
4. Northrop, R.B., “Introduction to Instrumentation and Measurements”, Taylor & Francis, New Delhi, 3rd Edition, 2017.
5. Carr, J.J., “Elements of Electronic Instrumentation and Measurement”, Pearson India Education, New Delhi, 2011.
6. Sawhney, A.K., “A Course in Electrical & Electronic Measurements & Instrumentation”, Dhanpat Rai and Co, New Delhi, 2015.
7. Kalsi, H.S.,” Electronic Instrumentation”, Tata McGraw-Hill, New Delhi, 3rd Edition, 2017.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s											PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	-	1	1	1	-	3	3	1	2	3	3	3
CO2	3	3	3	-	1	1	1	-	3	3	1	2	3	3	3
CO3	3	3	3	-	1	1	1	-	3	3	1	2	3	3	3
CO4	3	3	3	-	1	1	1	-	3	3	1	2	3	3	3
CO5	3	3	3	-	1	1	1	-	3	3	1	2	3	3	3
CO6	3	3	3	-	1	1	1	-	3	3	1	2	3	3	3
Avg.	3	3	3	-	1	1	1	-	3	3	1	2	3	3	3

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23405 UNIT OPERATIONS IN PROCESS INDUSTRIES

L	T	P	C
3	0	0	3

UNIT – I COMMON UNIT OPERATIONS IN PROCESS INDUSTRIES -I 9L

Unit Operation, Measurement and Control: - Transport of solid, liquid and gases – Evaporators Crystallizers-Dryers.

UNIT – II COMMON UNIT OPERATIONS IN PROCESS INDUSTRIES – II 9L

Operations On Fluids: Mixing and agitation: Mixing of liquids, selection of suitable mixers; Separation: Gravity settling, sedimentation, double cone classifier, centrifugal separation; Cyclones – Operation, equipment, control and applications.

UNIT – III HEAT TRANSFER AND ITS APPLICATIONS 9L

Heat exchangers: Single pass and multi pass heat exchangers, condensers, reboilers, Combustion process; Distillation: Binary distillation, Batch distillation, controls and operations, Chemical reactors.

UNIT – IV CASE STUDY 9L

Process flow diagram of paper and pulp industry – Batch digestor – Control problems on the paper machine. Process flow diagram of Petro Chemical Industry - Gas oil separation in production platform – Fractionization Column – Catalytic Cracking unit

UNIT – V CASE STUDY 9L

Unit Operations and Control schemes applied to Thermal Power plant, Steel Industry, Leather Industry.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

1. Apply the knowledge on various methods of transportation of fluids and liquids.
2. Select and apply relevant handling techniques to convert the solids and fluids for specific applications.
3. Come out with solutions for simple/complex problems in heat transfer and design the heat exchange equipment for different applications such as distillation, boilers.
4. Able to carry out multidisciplinary projects using heat transfer, mass transfer concepts.
5. Gain ability for lifelong learning of new techniques and developments in various types of unit operations in industries.

REFERENCES:

1. Balchen ,J.G., and Mumme, K.J., "Process Control structures and applications", Van Nostrand Reinhold Co., New York, 1988.
2. Warren L. McCabe, Julian C. Smith and Peter Harriot, "Unit Operations of Chemical Engineering", McGraw-Hill International Edition, New York, 6th Edition, 2001.
3. James R.couper, Roy Penny, W., James R.Fair and Stanley M.Walas, "Chemical Process Equipment :Selection and Design", Gulf Professional Publishing, 2010.
4. Waddams, A.L., "Chemicals from petroleum", Butler and Taner Ltd., UK, 1968.
5. Liptak, B.G., "Process measurement and analysis", Chilton Book Company, USA, 1995.
6. Luyben W.C., "Process Modeling, Simulation and Control for Chemical Engineers", McGraw-Hill International Edition, USA, 1989.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	-	2	-	-	2	2	-	-	-	-	-	3	-	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	-	-
CO4	3	3	3	3	2	-	-	2	2	2	-	-	3	-	-
CO5	3	2	2	-	-	-	-		-	-	-	3	3	-	-
Avg.	3	2.75	2.4	3	2	2	2	2	2	2	-	3	3	-	-

1- low, 2-medium, 3-high, '-"- no correlation

SELF-LEARNING COURSE

EI23501 **INDUSTRIAL INSTRUMENTATION- I**

L	T	P	C
3	0	2	4

UNIT – I MEASUREMENT OF FORCE, TORQUE, ACCELERATION AND DENSITY 9L, 6P

Different types of load cells: Hydraulic, Pneumatic, Magneto-elastic and Piezoelectric load cells - Different methods of torque measurement: Relative angular twist - Accelerometers: Seismic type: Piezoelectric, Strain gauge - Density and specific gravity: Baume scale and API scale –Pressure type, Float type, Ultrasonic and gas densitometer.

PRACTICALS:

- Measurement of torque, speed and density.

UNIT – II PRESSURE MEASUREMENT 9L, 9P

Units of pressure – Manometers - Elastic type: Bourdon tube, Bellows, Diaphragms and Capsules – Application: Diaphragm with strain gauges, Capacitive type, Piezo resistive - Measurement of vacuum: McLeod gauge, Thermal conductivity gauge, Iionization gauges – Pressure gauge selection, installation and calibration: dead weight tester - Pressure Transmitters: Conventional and Smart.

PRACTICALS:

- Configuration and calibration of differential pressure transmitter using HART communicator.
- Calibration of pressure gauge using dead-weight tester.
- Calibration of pressure gauge and pressure transmitter using handheld Pressure Calibrator.

UNIT – III TEMPERATURE MEASUREMENT 9L, 9P

Primary and secondary fixed points – Calibration - Filled in system thermometers –– Bimetallic thermometers – IC sensors – Thermocouples: Laws of thermocouple, Types, Reference junctions compensation, Signal conditioning – Radiation fundamentals – Total radiation pyrometers – Optical pyrometers – Two color radiation pyrometers –Fiber optic sensor for temperature measurement – Thermograph, Temperature switches –- Smart Temperature Transmitter.

PRACTICALS:

- Configuration and Calibration of temperature transmitter using temperature calibrator.
- Calibration and measurement of temperature using IR thermometer.
- Study of thermal imager.

UNIT – IV LEVEL MEASUREMENT 9L, 6P

Level measurement: Float gauges – Displacer type – Bubbler system – Load cell –Conductivity sensors – Capacitive sensors – Differential pressure methods, Elevation suppression – Nucleonic gauge – Radar type - Ultrasonic gauge – Solid level measurement - smart level transmitter.

PRACTICALS:

- Level measurement using differential pressure transmitter including suppression and elevation.
- Study of different types of level measuring instruments.

UNIT – V SYSTEM EVALUATION 9L

Implementation of Redundancy in Instrumentation Systems - Hot/cold/warm redundancy (Sensors/actuators/processes) - maintainability - Maintenance Strategies - Condition based monitoring.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Define different measurement techniques used in industries. (L1)
2. Describe the construction and operation of various measuring instruments. (L2)
3. Select suitable measuring instrument for a given application. (L3)
4. Decide a suitable signal conditioning circuit and choose a compensation technique for a measuring instrument. (L5)
5. Appraise different field transmitter and apply appropriate procedure for Calibration, installation and trouble shooting of a measuring device. (L3, L4)
6. Understand the need for redundancy and acquire relevant knowledge on condition monitoring. (L1, L2)

REFERENCES:

1. Doebellin, E.O. and Manik D.N., “Measurement systems Application and Design”, Tata McGraw Hill Education Pvt. Ltd, 5th Edition, 2011.
2. Jones. B.E., Jones’s Instrument Technology”, Vol.2, Butterworth-Heinemann, Elsevier, 4th Edition, 2016.
3. Liptak, B.G., “Instrumentation Engineers Handbook (Measurement)”, CRC Press, 4th Edition, 2012.
4. Patranabis, D., “Principles of Industrial Instrumentation”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2017.
5. Eckman D.P., “Industrial Instrumentation”, Wiley Eastern Limited, 2016.
6. Singh,S.K., “Industrial Instrumentation and Control”, Tata Mc-Graw-Hill Education Pvt. Ltd., 3rd Edition, New Delhi, 2010.
7. Alok Barua, “Lecture Notes on Industrial Instrumentation”, NPTEL, E-Learning Course, IIT Kharagpur.
8. Jayashankar, V., “Lecture Notes on Industrial Instrumentation”, NPTEL, E-Learning Course, IIT Madras.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	-	1	1	-	2	2	1	2	3	1	-
CO2	3	3	3	3	-	1	1	-	2	2	1	2	3	1	-
CO3	3	3	3	3	-	1	1	-	2	2	1	2	3	1	-
CO4	3	3	3	3	-	1	1	-	2	2	1	2	3	1	-
CO5	3	3	3	3	-	1	1	-	2	2	1	2	3	1	-
CO6	3	3	3	3	-	1	1	-	2	2	1	2	3	1	-
Avg.	3	3	3	3	-	1	1	-	2	2	1	2	3	1	-

1- low, 2-medium, 3-high, ‘-“- no correlation

EI23502 DISCRETE TIME SIGNAL PROCESSING

L	T	P	C
3	0	0	3

UNIT – I REVIEW OF DTFT AND ZT 9L

DTFT and Inverse DTFT: Definition and Properties. ZT and Inverse ZT: Definition and Properties. Solution of Difference Equations using DTFT and ZT. Relation between DTFT and ZT. Stability and Causality analysis using DTFT and ZT.

UNIT – II DFT AND FFT 9L

DFT and IDFT: Definition, properties, Direct computation of DFT, Circular convolution, Linear and circular convolution, Convolution of long duration sequences, Aliasing effects. FFT: Radix-2 DIT and DIF algorithms, computational complexity, DFT and IDFT computation using FFT algorithms.

UNIT – III DIGITAL IIR FILTERS 9L

Analog filters – Butterworth filters and Chebyshev Type I filters (up to 3rd order), Transformation of analog filters into equivalent digital filters using Impulse invariance method and Bilinear Transformation method- Realization structures for IIR filters – direct, cascade, parallel forms.

UNIT – IV DIGITAL FIR FILTERS 9L

Advantages of FIR over IIR filters, Linear Phase FIR filters, FIR filter design using Fourier Series Method and Windowing method, Realization structures for FIR filters – Transversal and Linear phase structures.

UNIT – V FINITE WORD LENGTH EFFECTS 9L

Finite word length effect in Fixed and Floating point representation of numbers, ADC quantization noise, Coefficient quantization error, Truncation and Rounding errors, Limit cycle oscillation due to overflow in digital filters.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Recall the concept of DTFT and ZT for analysis of DT signals and systems. (L1)
2. Analyze the spectral characteristics of DT signals using FFT tools. (L4)
3. Design IIR filter for given specifications and evaluate its performance. (L5)
4. Design FIR filter using proper choice of window and evaluate its performance. (L5)
5. Infer the finite word length effects due to various sources in the DT systems. (L2)
6. Solve problems in Discrete Time signal processing. (L3)

REFERENCES:

1. Ronald W Schafer and Alan V Oppenheim, "Discrete - Time Signal Processing ", First Edition, ISBN No. 978-9332550339, Pearson Education India, Jan 2015.
2. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4th Edition, ISBN No. 978-9332535893, Pearson Education, Jan 2014.
3. Sanjit K. Mitra," Digital Signal Processing: A Computer-based approach", McGraw-Hill Education, 4th Edition, ISBN No. 978-1259098581, July 2013.

4. Vinay K. Ingle | John G. Proakis, "Digital Signal Processing Using Matlab® : A Problem-Solving Companion", Cengage India, 4th Edition, ISBN No. 9789386668110, Dec 2017.
5. NPTEL Video Lecture Series on "Discrete Time Signal Processing" by Prof. Mrityunjoy Chakraborty, https://onlinecourses.nptel.ac.in/noc22_ee28/preview

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	3	2	1	1	1	1	1	-	2	-	1	1
CO2	3	2	1	3	2	1	1	1	1	1	-	2	2	1	1
CO3	3	3	1	3	3	1	2	1	1	1	-	2	-	1	1
CO4	2	3	1	3	3	1	2	1	1	1	-	2	2	3	1
CO5	2	3	2	3	2	1	1	1	1	1	-	2	-	3	1
CO6	3	3	2	3	2	2	2	1	1	1	-	2	3	3	1
Avg.	2.7	2.7	1.3	3	2.3	1.2	1.5	1	1	1	-	2	1.7	2	1

1 - low, 2-medium, 3-high, '-"- no correlation

EI23503	CONTROL SYSTEM ANALYSIS AND DESIGN	L	T	P	C
		3	0	2	4

UNIT – I MODELING OF LINEAR TIME INVARIANT SYSTEM (LTIV) 9L, 9P

Control system: Open loop and Closed loop – Feedback control system characteristics – First principle modeling: Mechanical, Electrical and Hydraulic systems–Transfer function representations- Block diagram and Signal flow graph.

PRACTICALS:

- Familiarization of control systems toolbox
- Determination of time and frequency responses of a LTI system. (Mechanical, Electrical, Electro mechanical and Hydraulic system)

UNIT – II STATESPACE MODEL OFLTIV AND LTV SYSTEMS 9L, 6P

State variable formulation– Non uniqueness of state space model – State transition matrix –Free and forced responses for Time Invariant and Time Varying Systems – Controllability – Observability- State Observer-State Feedback Control

PRACTICALS:

- Testing of Controllability and Observability of a LTI system.
- Desig and implementation of state feedback control scheme for a MIMO system.

UNIT – III TIME DOMAIN AND STABILITY ANALYSIS 9L, 3P

Standard test inputs – Time responses – Time domain specifications – Stability analysis: Concept of stability–Routh Hurwitz stability criterion–Root locus: Construction and Interpretation - software tools.

PRACTICALS:

- Time domain analysis of open loop unstable system (Inverted Pendulum/Ball balancing Table/TRMS)

UNIT – IV FREQUENCY DOMAIN ANALYSIS 9L, 3P

Bode plot, Polar plot and Nyquist plot: Construction, Interpretation and stability analysis – Frequency domain specifications- closed loop frequency response analysis - software tools.

PRACTICALS:

- Frequency response analysis of an open loop / closed loop stable systems.

UNIT – V DESIGN OF FEEDBACK CONTROL SYSTEM 9L, 9P

Design specifications–Lead, Lag and Lag-lead compensators using Root locus and Bode plot technique - software tools.

PRACTICALS:

- Design, Analysis and implementation of lag and lead compensators using Bode and Root locus for a physical system.
- Design, Analysis and implementation of lag-lead compensator using Bode and Root locus for a physical system.

TOTAL: 45 L + 30 P = 75 PERIODS

COURSE OUTCOMES:

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

1. Classifyand interpret various types of control system. (L1, L2)
2. Develop various representations of system based on the first principles approach. (L3)
3. Interpret response on LTIV and LTV systems. (L3)
4. Interpret time and frequency responses and infer the time domain and frequency domain specifications from the response. (L3)
5. Construct, analyze and infer the stability of root locus, Bode plot, polar plot and Nyquist plot. (L5)
6. Design and implement lag, lead, lag-lead compensators to meet the time and frequency domain specifications. (L4)

REFERENCES:

1. Benjamin C.Ku and Farid Golnaraghi, "Automatic Control Systems", McGraw-Hill Education, 10th Edition, 2017.
2. .Nagarath,I.J. and Gopal,M., "Control Systems Engineering", New Age International Publishers, 6th Edition, 2017.
3. Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, "Control System Design", 2002.
4. Richard C. Dorfand Robert H. Bishop, "Modern Control Systems", Education Pearson, 13th Edition, 2017.
5. John J.D., Azzo Constantine, H. and Houpis Sttuart, N Sheldon, "Linear Control System Analysis and Design with MATLAB", CRC Taylor & Francis, Reprint, 2014.
6. Katsuhiko Ogata, "Modern Control Engineering", PHI Learning Private Ltd, Pearson, 5th Edition, 2015.
7. NPTEL Video Lecture Noteson "Control Engineering "by Prof. S.D. Agashe, IIT Bombay.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	-	-	-	-	-	1	-	-	-	-	-	-	3
CO2	3	1	3	-	2	-	-	1	-	-	-	-	-	-	3
CO3	3	-	3	3	2	-	-	1	-	-	-	-	-	-	3
CO4	3	3	-	3	2	-	-	1	-	-	-	-	-	-	3
CO5	3	3	-	3	2	-	-	1	-	-	-	-	-	-	3
CO6	3	3	3	3	2	-	-	1	-	-	-	-	-	-	3
Avg.	3	2.2	3	3	2	-	-	1	-	-	-	-	-	-	3

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23504	EMBEDDED SYSTEM DESIGN	L T P C
		1 0 4 3

LIST OF EXPERIMENTS

Practical Module–1 Introduction to Embedded Hardware

Objective
- To introduce embedded system and its fundamental buildingblocks
- To make the students familiar with the architectural features and instruction set of microcontrollers/microprocessors

Demonstration
- Overview of on-board peripherals of the embedded trainer kit

Experiment
1. Arithmetic exercises through assembly language programming.
2. Implementation of certain tasks on microcontroller using assembly language.

Exercise
1. Sorting an array and code conversions.
2. Solving simple mathematical expressions.

Practical Module–2 Introduction to Embedded C programming

Objective
- To introduce Embedded C programming and its fundamental building blocks
- To make the students effectively utilize the versatile features of Embedded C programming for embedded applications

Demonstration
- Building the source code for the required application on an Integrated Development Environment and loading the same onto the chosen microcontroller through In System Programming.

Experiment
1. Simple exercises through Embedded C Programming.
2. Implementation of certain tasks on microcontroller using Embedded C.

Exercise
1. Development of simple applications using recursion.
2. Design of simple calculator.

Practical Module–3 Interfacing of input devices

Objective
- To realize the significance of I/OPorts of microcontrollers
- To provide an insight over interfacing different kinds of input devices that include push-buttons, switches and keypad with microcontrollers

Demonstration
- Interfacing hex keypad with microcontroller

Experiment
1. Interfacing push-button/SPST/SPDT switches with microcontroller.
2. Interfacing Limit switch with microcontroller.

Exercise
1. Design of simple calculator using 4x4 keypad.
2. Simple control applications using level/pressure limit switches.

Practical Module–4 Interfacing of output devices

Objective
- To interface various output devices such as actuators and display devices and their applications
- To sensitize the students about the need for driver circuitry

Demonstration 1. Interfacing LED with microcontroller

Experiment
1. Interfacing LCD/Seven segment LED with microcontroller.
2. ON/OFF control of field device using microcontroller.

Exercise
1. Simple DC/Stepper motor speed/direction control using suitable driver module
2. Control of solenoid valve using relay

Practical Module–5 Timers/Counters

Objective
- To make the students understand the concept of on-chip Timers/Counters
- To enable the students to configure the Timer/ Counter and familiarize with scaling concepts

Demonstration
- Configuration of Timers with and without scaling

Experiment
1. ON/OFF control of field device at the prescribed time interval using Timers.
2. Event counting using Timers.

Exercise
1. Frequency measurement using Timer/Counter.

Practical Module–6 Interrupts

Objective
- To make the students understand the concept of interrupts and their classifications.
- To inculcate the students towards the potential use of interrupts in embedded applications

Demonstration
- Interrupt generation and masking

Experiment
1. Interrupt driven ON/OFF control of field device.
2. Design of ON/OFF control strategy for a given process using Timers and Interrupts.

Exercise
1. Prioritized interrupt generation for control applications

Practical Module-7 ADC Interface

Objective
- To make the students understand the operational features of various types of DACs.
- To provide an insight over data acquisition to carry out signal processing.

Demonstration
- Interfacing external/internal ADC with microcontroller using EDA software.

Experiment
1. Real time process data acquisition by interfacing external ADC with microcontroller.
2. Real time process data acquisition using internal ADC of microcontroller.

Exercise
1. Data acquisition using various types of ADCs

Practical Module–8 DAC Interface

Objective	• To make the students understand the operational features of various types of DACs. • To provide an insight over data reconstruction to perform closed loop control.
Demonstration	• Interfacing external/internal DAC with microcontroller using EDA software
Experiment	1. Generation of continuous signal by interfacing external DAC with microcontroller. 2. Generation of continuous signal using internal DAC of microcontroller.
Exercise	1. Design of smart transmitter.

Practical Module–9 PWM Generation

Objective	• To make the students understand the operational behavior of CCP modules. • To orient the students towards the generation of PWM signal for control applications
Demonstration	• Timing and control of events using CCP modules
Experiment	1. Generation of PWM signal with different duty cycles. 2. Speed control of DC motor using PWM.
Exercise	1. Generation of Special Event Trigger

Practical Module–10 Wired Communication Modules

Objective	• To make the students familiarize with synchronous and asynchronous data communication • To impart knowledge on establishing communication between microcontrollers and peripherals using appropriate wired communication protocols
Experiment	1. Establishing communication between microcontrollers using RS232/RS485. 2. Interfacing RTC with microcontroller using I^2C/SPI interface.
Exercise	1. Interfacing I^2C/SPI enabled ADC with microcontroller. 2. Interfacing I^2C/SPI enabled DAC with microcontroller.

Practical Module–11 Wireless Communication Modules

Objective	• To introduce various wireless communication protocols • To facilitate the students to transmit field parameters using wireless communication protocols
Experiment	1. Process data transmission using Zigbee. 2. Process data transmission using LoRa.
Exercise	1. Zigbee enabled home automation. 2. LoRaWAN enabled building automation.

Practical Module–12 IoT Enabled Field Sensing

Objective	• To impart knowledge on the inherent features of IoT gateways for embedded applications • To enable the students to carry out IoT enabled data acquisition
Demonstration	• IoT application development using Python

Experiment 1. IoT enabled field sensing using Raspberry Pi.
2. IoT enabled field sensing using ESP32.

Exercise 1. Design of IoT enabled transmitter.

TOTAL : 75 PERIODS

COURSE OUTCOMES

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

1. Infer the concept of embedded system and its architectural features. (L2)
2. Recognize the core concept of Embedded C programming and its significance in embedded applications. (L2)
3. Interface real world input field devices with microcontrollers. (L3)
4. Interface real world actuators and display units with microcontrollers. (L3)
5. Configure and utilize the services of timers for a given embedded application. (L3)
6. Understand the concept of interrupt and utilize it for embedded applications. (L3)
7. Use suitable data converters for data acquisition and signal processing. (L3)
8. Perform signal reconstruction for closed loop control applications. (L3)
9. Generate PWM signals for control applications. (L3)
10. Choose appropriate wired communication protocol for a given embedded application. (L4)
11. Select suitable wireless communication protocol for a given embedded application. (L4)
12. Accomplish real time remote field sensing using the concept of IoT. (L3)

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
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CO3	3	3	3	1	-	-	-	1	3	3	3	3	1	3	1
CO4	3	3	3	1	-	-	-	1	3	3	3	3	1	3	1
CO5	3	3	3	1	-	-	-	1	3	3	3	3	1	3	1
CO6	3	3	3	1	-	-	-	1	3	3	3	3	1	3	1
CO7	3	3	3	2	2	-	-	1	3	3	3	3	1	3	1
CO8	3	3	3	2	2	-	-	1	3	3	3	3	1	3	1
CO9	3	3	3	2	-	-	-	1	3	3	3	3	1	3	1
CO10	3	3	3	2	2	-	-	1	3	3	3	3	1	3	1
CO11	3	3	3	2	2	-	-	1	3	3	3	3	1	3	1
CO12	3	3	3	3	3	2	2	1	3	3	3	3	1	3	1
Avg	3	3	3	1.6	2.3	2	2	1	3	3	3	3	1	3	1

1-Low, 2-Medium, 3-High, '-"- no correlation

UC23E01 ENGINEERING ENTREPRENEURSHIP DEVELOPMENT

L	T	P	C
2	0	2	3

COURSE OBJECTIVES:

1. Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
2. Apply process of problem - opportunity identification and validation through human centred approach to design thinking in building solutions as part of engineering projects
3. Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
4. Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
5. Prepare and present an investible pitch deck of their practice venture to attract stakeholders

MODULE – I: ENTREPRENEURIAL MINDSET 4L,8P

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economies – Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

MODULE – II: OPPORTUNITIES 4L,8P

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society – Creation of opportunities – Exploring Market Types – Estimating the Market Size, - Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities

Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.

MODULE – III: PROTOTYPING & ITERATION 4L,8P

Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques.

Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the prototypes.

MODULE – IV: BUSINESS MODELS & PITCHING 4L,8P

Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest Assumptions in Business Model Design – Using Business Model Canvas as a Tool – Pitching Techniques: Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention.

Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback

MODULE – V: ENTREPRENEURIAL ECOSYSTEM 4L,8P

Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem - Building the right stakeholder network

Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers; angels; etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types

CO2: Comprehend the process of opportunity identification through design thinking, identify market potential and customers

CO3: Generate and develop creative ideas through ideation techniques

CO4: Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP

CO5: Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

REFERENCES:

1 Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Sabyasachi Sinha (2020). Entrepreneurship, McGrawHill, 11th Edition

2. Bill Aulet (2024). Disciplined Entrepreneurship: 24 Steps to a Successful Startup. John Wiley & Sons.

3. Bill Aulet (2017). Disciplined Entrepreneurship Workbook. John Wiley & Sons.

4. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business

5. Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch

6. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons

7. Marc Gruber & Sharon Tal (2019). Where to Play: 3 Steps for Discovering Your Most Valuable Market Opportunities. Pearson.

EI23501 **INDUSTRIAL INSTRUMENTATION- II**

L	T	P	C
3	0	2	5

COURSE OBJECTIVES:

•

UNIT – I **MEASUREMENT OF VISCOSITY, HUMIDITY AND MOISTURE** **9L,6P**

Viscosity: Capillary viscometer - Saybolt viscometer – Rotameter type and Torque type viscometers – Consistency Meters – Humidity: Dry and wet bulb psychrometers – Resistive and capacitive type hygrometers – Dew point meters. Methods of Moisture measurements: Thermal, Conductivity, Capacitive, Microwave, IR and NMR sensors, Application of moisture measurement – Moisture measurement in solids

PRACTICALS

- Measurement of Viscosity using Brook Field Viscometer.
- Measurement of humidity using Dry and wet bulb psychrometers.

UNIT – II **VARIABLE HEAD TYPE FLOWMETERS** **9L,9P**

Expression for flow rate through restriction (compressible and incompressible flow) – Orifice plate –different types of orifice plates – Cd variation – Pressure tapings – Venturi tube – Flow nozzle – Dall tube – Elbow taps – Pitot tube: combined and averaging pitot tube – installation and applications - Smart Flow Transmitter.

PRACTICALS

- Calculation of discharge coefficient of orifice and venturi meter installed in a pipeline.
- Development of Software Program for sizing Orifice.

UNIT – III **QUANTITY METERS, AREA AND MASS FLOW METERS** **9L, 9P**

Positive displacement flow meters: Nutating disc, Reciprocating piston and Oval gear flow meters – Inferential meter: Turbine flow meter – Variable Area flow meter: Rota meter theory, characteristics, installation and applications – Mass flow meter: Angular momentum, Thermal and Coriolis type – Calibration: Dynamic weighing method.

PRACTICALS

- Sizing of Rotameter.
- Calibration of Rotameter.

UNIT – IV **ELECTRICAL TYPE FLOW METERS** **9L, 6P**

Principle and constructional: Electromagnetic flow meter – Ultrasonic flow meters – Laser Doppler anemometer – Vortex shedding flow meter – Target flow meter – Guidelines for selection of flow meter – Open channel flow measurement – Solid flow rate measurement.

PRACTICALS

- Study of different types of flow instruments.
- Interfacing Different types of flow meter with PC using DAQ.

UNIT – V SAFETY INSTRUMENTATION 9L

Introduction to Safety Instrumented Systems – Process Hazards Analysis (PHA) – Safety Life Cycle – Control and Safety Systems - Safety Instrumented Function - Safety Integrity Level (SIL) – Selection, Verification and Validation of SIL.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Choose appropriate instrument for a given process measurement problem. (L1)
2. Describe the construction and working principles of instruments used for measurement of flow, viscosity, humidity and moisture. (L2)
3. Select and apply appropriate concepts and methods to solve Industrial problems effectively. (L3)
4. Apply appropriate procedure for Calibration, installation and troubleshooting of a measuring device. (L3)
5. Choose appropriate field transmitter for sensing different parameter in industrial environment. (L5)
6. Capable of doing Process hazard analysis and 2etermining appropriate SIL for an application. (L2, L4)

REFERENCES:

1. Liptak, B.G., "Instrumentation Engineers Handbook (Measurement)", CRC Press, 4th Edition, 2012.
2. Doebellin, E.O. and Manik D.N., "Measurement systems Application and Design", Tata McGraw Hill Education Pvt. Ltd, 5th Edition, 2011.
3. Patranabis, D., "Principles of Industrial Instrumentation", Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2017.
4. King, R, "Safety in the process industries", Elsevier, 2016.
5. Cepin, M., & Bris, R., "Safety and reliability. Theory and applications", CRC Press, 2017.
6. Jain, R.K., "Mechanical and Industrial Measurements: Process Instrumentation and Control", Khanna Publishers, Delhi, 2008.
7. Singh, S.K., "Industrial Instrumentation and Control", Tata McGraw Hill Education Pvt. Ltd., 3rd Edition, New Delhi, 2010.
8. Jayashankar, V., "Lecture Notes on Industrial Instrumentation", NPTEL, E-Learning Course, IIT Madras.
9. Bahadori, A. Hazardous area classification in petroleum and chemical plants: a guide to mitigating risk, CRC Press, 2013.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	2	1	1	-	-	-	1	1	3	3	-
CO2	3	3	3	3	2	1	1	-	-	-	1	1	3	3	-
CO3	3	3	3	3	2	1	1	-	-	-	1	1	3	3	-
CO4	3	3	3	3	2	1	1	-	-	-	1	1	3	3	-
CO5	3	3	3	3	2	1	1	-	-	-	1	1	3	3	-
CO6	3	3	3	3	2	1	1	-	-	-	1	1	3	3	-
Avg.	3	3	3	3	2	1	1	-	-	-	1	1	3	3	-

1- low, 2-medium, 3-high, '-"- no correlation

EI23602 **PROCESS CONTROL**

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

-

UNIT – I PROCESS DYNAMICS 9L, 6P

Need for process control – Hierarchical decomposition of control functions – Servo and regulatory operations – Continuous and Batch processes – Mathematical Modeling of Processes: Level, Flow and Thermal processes – Lumped and Distributed parameter models – Degrees of Freedom – Interacting and non-interacting systems – Self regulation – Linearization of non-linear systems.

PRACTICALS:

- Design and implementation of controller for the Interacting and non-interacting pilot experimental setup.
- Simulation of lumped and distributed parameter systems.

UNIT – II CONTROL VALVE 9L, 6P

Actuators: Pneumatic and electric actuators – I/P converter – Control Valve Terminology - Characteristic of Control Valves: Inherent and Installed characteristics - Valve Positioner – Modeling of a Pneumatically Actuated Control Valve – Valve body: Commercial valve bodies – Control Valve Sizing: ISA S 75.01 standard flow equations for sizing Control Valves – Cavitation and flashing– Control Valve selection.

PRACTICALS:

- Determination of characteristics of a Pneumatically Actuated Control valve (with and without Positioner) in the experimental setup.

UNIT – III CONTROL ACTIONS 9L, 6P

Characteristic of ON-OFF, Proportional, Single speed floating, Integral and Derivative controllers – P+I, P+D, P+I+D, PIDA control modes – Practical forms of PID Controller –PID Implementation Issues: Bumpless Auto/manual Mode transfer, Anti-reset windup Techniques and Direct/reverse action– Introduction to Fractional order PID.

PRACTICALS:

- Implementation of ON-OFF controller for a temperature process
- Implementation of Practical form of PID in simulation

UNIT – IV PID CONTROLLER TUNING AND ADVANCED CONTROL SYSTEMS 9L, 6P

PID Controller Design Specifications: Criteria based on Time Response and Frequency Response - PID Controller Tuning: Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method, Auto tuning – Cascade control –selective control – Feed-forward control – Ratio control – Inferential control – Split-range– Adaptive Control.

PRACTICALS:

- Control of Level, Pressure and Flow using industrial type PID controller.

- Design and Implementation of Feed forward and Cascade control schemes on the simulated model of a typical Industrial Process.

UNIT – V MODEL BASED CONTROL SCHEMES & INTRODUCTION TO MULTI-LOOP REGULATORY CONTROL & CASE –STUDIES 9L, 6P

Smith Predictor Control Scheme - Internal Model Controller – IMC PID controller –Model Predictive Control- Introduction to Multi-loop Control Schemes – Control Schemes for Distillation Column, pH-Three-element Boiler drum level control.

PRACTICALS:

- Design and implementation of Multi-loop PID schemes on the simulated model of a Typical Industrial Process.
- Interpretation of P & ID (ISA S5.1).

TOTAL: 45L+ 30P= 75 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/ Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. List the hardware involved in a control system.
2. Find the importance of digital computers for the present and future implementation of advanced control techniques.
3. Outline the steps that should be considered during the development of a mathematical model for chemical processes.
4. Analyze the strengths and weaknesses of a feedback control system using MATLAB software.
5. Elaborate your answer how the stability characteristics of the closed loop response of a cascade control system is better than simple feedback.
6. Examine the similarities and differences between MRAC and STRs using MATLAB software.
7. Explore various types of controllers presently used in industries.

COURSE OUTCOMES:

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

1. Develop models using first principles approach for processes such as level, flow, temperature and pressure etc, verify and analyze these models through simulation. (L5)
2. Recommend the right type of control valve along with its characteristics for a given application. (L5)
3. Design Size a control valve following the procedure outlined in the ISA S 75.01 standard. (L5)
4. Design & implement a suitable control scheme for a given process and validate through simulations & in Real time with the experimental setups. (L5)
5. Analyze various advanced control schemes and recommend the right control strategy for a given SISO/MIMO application. (L4)
6. Use appropriate software tools (Example: MATLAB/SCILAB) for analysis, design and implementation of Process Control System. (L5)

REFERENCES:

1. Raghunathan Rengaswamy, Babji Srinivasan, Nirav Pravinbhai Bhatt, “Process Control Fundamentals: Analysis, Design, Assessment, and Diagnosis”, CRC press, 1st Edition, 2020.
2. Seborg, D.E., Mellichamp, D.P., Edgar, T.F., and Doyle, F.J., III, “Process Dynamics and Control”, John Wiley and Sons, 4th Edition, 2017.
3. George Stephanopoulos, “Chemical Process Control – An Introduction to Theory and Practice”, Prentice Hall of India, 2005.
4. Bequette, “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, 1st Edition, 2013.

5. Thomas Marlin "Process Control: Designing Processes and Control Systems for Dynamic Performance", New York: McGraw-Hill, New York, 2nd Edition, 2000.
6. Bela G.Liptak, "Process Control: Instrument Engineers' Handbook" Butterworth-Heinemann, 3rd Edition, 2013.
7. Aidan O'Dwyer, "Handbook of PI and PID Controller Tuning Rules", Imperial College Press; 3rd Edition, 2009.
8. Antonio Visioli, "Practical PID Controller", Springer Publisher, London, 2009.

List of Open Source Software/ Learning website:

1. https://plcip-coep.vlabs.ac.in/List%20of%20experiments.html
2. https://plchla-coep.vlabs.ac.in/List%20of%20experiments.html
3. https://plctt-coep.vlabs.ac.in/List%20of%20experiments.html
4. https://plccom-coep.vlabs.ac.in/
5. https://pc-coep.vlabs.ac.in/List%20of%20experiments.html
6. http://38.100.110.143/vlabiitece/exp7.php
7. https://nptel.ac.in/courses/103106148
8. https://nptel.ac.in/courses/103105064
9. https://nptel.ac.in/courses/103103037

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	-	-	-	2	-	-	1	-	1	-	-	-	3	2
CO2	3	3	3	-	2	-	-	1	-	1	-	-	-	3	2
CO3	3	2	-	3	2	-	-	1	-	1	-	-	-	3	2
CO4	3	2	3	-	3	-	-	1	-	1	-	-	-	3	2
CO5	3	3	3	-	3	-	-	1	-	1	-	-	-	3	2
CO6	3	3	-	3	2	-	-	1	-	1	-	-	-	3	2
Avg.	3	2.6	3	3	2.3	-	-	1	-	1	-	-	-	3	2

1-low, 2-medium, 3-high, '-" - no correlation

EI23603	INDUSTRIAL DATA COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

-

UNIT – I DATA NETWORK AND INTERNET FUNDAMENTALS 9L

ISO/OSI Reference model – TCP/IP Protocol Stack – UDP – Transport Layer Security [Network security and cryptography] – Virtual Private Network – EIA 232 interface standard – EIA 485 interface standard – CAN [Controller Area Network] and CAN FD – Media access protocol: Command/response, CSMA/CD –– IEEE 802.3 – Bridges –Routers –Gateways– Standard ETHERNET configuration.

UNIT – II MODBUS AND HART 9L

Evolution of industrial data communication standards – MODBUS:- Protocol structure, Function codes – HART communication protocol, Communication modes, HART Networks, HART commands, HART applications & Troubleshooting -

UNIT – III PROFIBUS AND FF 9L

Fieldbus: Fieldbus architecture, Basic requirements of Fieldbus standard, Fieldbus topology, Interoperability and Interchangeability. Introduction – Profibus protocol stack – Profibus communication model – Communication objects – Foundation field bus versus Profibus - EtherCAT protocol.

UNIT – IV AS – INTERFACE (AS-i), DEVICENET AND INDUSTRIAL ETHERNET 9L

AS interface: Introduction – Physical layer – Data link layer – Operating characteristics. Devicenet: Introduction – Physical layer – Data link layer and Application layer. Industrial Ethernet: Introduction – 10Mbps Ethernet – 100Mbps Ethernet- Gigabit Ethernet.

UNIT – V WIRELESS COMMUNICATION 9L

Wireless sensor networks: Hardware components – energy consumption of sensor nodes – Network architecture – sensor network scenario. Wireless MAC Standards– IEEE 802.11- IEEE 802.15.4 – Zigbee Wireless HART – Wireless Standard for Process Industry – ISA100 – Introduction to Industrial IOT – Low Power Wide Area Network (LPWAN), WiFi, low power Bluetooth for IoT and Industrial applications – Introduction to 5G concept.

TOTAL: 45 PERIODS

ACTIVITY BASED LEARNING:

1. MODSIM, MODSCAN based experiments.
2. Protocols implemented in python

COURSE OUTCOMES:

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

1. Explain Industrial data networking framework, their evolution associated hardware and software. (L1, L2)
2. Analyze and select proper protocol for device level and control level integration. (L4)
3. Design networking for process control applications and industrial automation. (L3)
4. Compare and choose a specific protocol for the given architecture. (L3)
5. Select and use the most appropriate networking technologies and standards for a given application. (L4)

6. Perceive the requirements of an industry and provide a wired or wireless solution for installing Industrial data network. (L5)

REFERENCES:

1. Mackay, S., Wright,E., Reynders,D., and Park,J., “Practical Industrial Data Networks: Design, Installation and Troubleshooting”, Newnes Publication, Elsevier, 1st Edition, 2004.
2. Buchanan,W., “Computer Busses: Design and Application”, CRC Press, 2000.
3. Bela G. Liptak, “Instrument Engineers’ Handbook, Volume 3 : Process Software and Digital Networks”, CRC Press, 4th Edition, 2011.
4. Kurose James F., Ross Keith W , “Computer Networking: A Top-Down approach”, Pearson Publications, 7th Edition, 2016.
5. Bowden, R., “HART Application Guide”, HART Communication Foundation, 1999.
6. Berge, J., “Field Buses for Process Control: Engineering, Operation, and Maintenance”, ISA Press, 2004.
7. Lawrence (Larry) M. Thompson and Tim Shaw, “Industrial Data Communications”, 5th Edition, ISA Press, 2015.
8. NPTEL Lecture notes on,” Computer Networks” by Department of Electrical Engg., IIT Kharagpur.
9. High Performance Browser Networking, Ilya Grigorik [Former Network Google Engineer and Freely available online – https://hpbn.co/]

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	2	1	-	-	-	1	-	-	-	-	-	-	3
CO2	2	1	2	1	-	-	-	1	-	-	-	-	-	-	3
CO3	2	1	3	1	-	-	-	1	-	-	-	-	-	-	3
CO4	2	1	3	1	-	-	-	1	-	-	-	-	-	-	3
CO5	2	1	3	1	-	-	-	1	-	-	-	-	-	-	3
CO6	2	1	3	1	-	-	-	1	-	-	-	-	-	-	3
Avg.	2	1	2.7	1	-	-	-	1	-	-	-	-	-	-	3

1-low, 2-medium, 3-high, ‘-“ - no correlation

EI23604	INDUSTRIAL AUTOMATION SYSTEMS LABORATORY	L	T	P	C
		1	0	4	3

LIST OF EXPERIMENTS

Practical Module – 1: Study of PLC architecture and Field Device Interface Modules (AI, AO, DI, DO Modules).

Objective(s) Impart knowledge on PLC architecture including CPU, I/O module, connecting I/O modules (DI/DO/AI/AO modules) to CPU, Power supply module and Communication module & Hot swapping, Industrial certifications.

Demonstration Configuration of a PLC.

Experiment(s)
1. Study of DI/DO/AI/AO modules of all PLCs.
2. Installation &Configuration of I/O modules.
3. Understanding one of the PLC Control panels wiring diagram and creating a control panel layout.

Assignment(s)
1. Comparison of all PLCs in the lab.
2. Market survey of the recent PLCs and comparison of their features with the PLCs available in the lab.

Practical Module – 2: Realization of discrete control sequence using Ladder Logic Programming

Objective(s)
1. Introduce students to Programming PLC using (IEC 61131-3) Programming languages
2. To make students familiarize and realize discrete control sequences using Ladder Logic Instruction set.

Demonstration Procedure for filling and draining of liquid in a single tank setup using Ladder Logic instruction set.

Experiment(s)
1. Implementation of Alarm annunciator sequence (ISA 18.1 Standard) using ladder logic programming.
2. Implementation of Ladder Logic program in components of Electro-pneumatic trainer.

Assignment(s)
1. Implementation of Traffic light control sequence using Ladder Logic programming.

Practical Module – 3: Realization of Discrete control sequences using Functional Block Diagram(FBD) Programming

Objective(s) Introduce students to FBD programming and make them to realize Discrete control sequences using Function blocks

Demonstration Demonstration of filling and draining of liquid in a single tank experimental setup using Function blocks.

Experiment(s)
1. Implementation of Alarm annunciator sequence (ISA 18.1 Standard) using FBD.
2. Implementation of Reversal of direction of rotation of DC motor using FBD.

Assignment(s)
1. Implementation of Traffic light control sequence using FBD.

Practical Module – 4: Realization of Discrete control sequences using ST, IL and SFC Programming methods.

Objective(s) Introduce students to ST, IL and SFC Programming methods and make them to realize Discrete control sequences using ST, IL and SFC.

Demonstration Demonstration of Traffic light control sequences using ST, IL and SFC programming methods.

Experiment(s) Implementation of Alarm annunciator sequence (ISA 18.1 Standard) using ST, IL and SFC programming methods.

Assignment(s)
1. Exercises covering all instruction set of IL, ST and SFC.
2. Reversal of direction of rotation of DC motor using ST, IL and SFC programming methods.

Practical Module – 5 Interfacing Analog/Digital Input/output Devices with Industrial Type PLC.

Objective(s) To introduce students on how to Interface transmitters, limit switches, final control elements with PLC.

Demonstration How to Interface field devices to a PLC – Case Study: How to interface field devices available in the filling and draining of liquid in a single tank experimental test setup to a PLC.

Experiment(s)
1. Interfacing Level Transmitter and Control valve with PLC.
2. Interfacing Limit switches and a Pump with PLC.

Assignment(s)
1. Interfacing Temperature Transmitter and Heater with PLC.
2. Interfacing Flow Transmitter and Variable-speed pump with PLC.

Practical Module – 6 Closed loop control of a typical process using PLC.

Objective(s) To introduce students on how to configure PID control block to achieve closed loop control.

Demonstration Configuration of PID Function Block.

Experiment On-line Monitoring and Control of Level Process using PLC.

Assignment(s) On-line Monitoring and Control of Processes such as Flow, Temperature and Pressure, using PLC.

Practical Module – 7 HMI/ SCADA Programming

Objective(s) SCADA/HMI development, configuration of face plates, creation of logs, Transmitter data trend displays, linking of tags with graphics.

Demonstration HMI/SCADA development for a Process.

Experiment(s) HMI/SCADA development for the Process Control Training Plant (Level/Flow Process).

Assignment(s) HMI/SCADA development for an induction motor speed control, Two axis servo motor control.

Practical Module-8 Architecture of DCS

Objective(s) Impart knowledge on DCS architecture including CPU, I/O module, connecting I/O modules (DI/DO/AI/AO modules) to CPU, Power supply module and Communication module & Hot swapping, Industrialcertification.

Demonstration Configuration of DCS.

Experiment(s)
1. Study of AI, AO, DI, DO, H1-interface modules of all DCSs.
2. Installation &Configuration of I/O modules.
3. Understanding any one of the DCS Control panels wiring diagram and creating a control panel layout.
4.

Assignment(s) Market survey of the recent DCSs and comparison of their features with the DCSs available in the lab.

Practical Module-9 Interfacing of field devices with DCS.

Objectives To introduce students on how to Interface transmitters, limit switches, final control elements with DCS.

Demonstration
1. How to Interface Level transmitter and Flow Transmitter in the Process Control Training Plant to a DCS.
2. How to interface Limit Switches, Pumps and Control valves in the Process Control Training Plant to a DCS.

Experiment(s)
1. Interfacing Temperature Transmitter and Variable Speed Pump to a DCS.
2. Configuration of face plates, creation of logs and trend displays.

Assignment(s) Interfacing Temperature Transmitter and Heater and Variable Speed Pump with Pump Controller to a DCS.

Practical Module-10. Realization of control schemes for typical processes using DCS

Objective To introduce students on how to configure PID control block to achieve closed loop control

Demonstration Configuration of PID Function Block and PID Faceplate

Experiment On-line Monitoring and Control of Level Process using Distributed Control System.

Assignment(s) On-line Monitoring and Control of Process such as Flow, Temperature and Pressure, using Distributed Control System.

Practical Module-11 Interfacing smart field devices with DCS.

Objective To introduce students on how to Interface smart field devices (HART/Foundation Field bus) with DCS.

Demonstration Demonstration of 'PID control' in field devices.

Experiment(s) Design and Implementation of Feedback control scheme (FF-PID) for the level process using DCS.

Assignment(s) Market survey: Industrial Data Networks.

Practical Module-12 IoT based monitoring of Level/Flow process

Objective(s) Introduction to IoT based monitoring.

Demonstration Configuration of IoT gateway.

Experiment(s)
1. Interfacing transmitters to DCS through IoT gateway.
2. Cloud based Monitoring of level/flow process.

Assignment(s) Cloud based Monitoring of temperature process.

TOTAL : 15 + 60 = 75 PERIODS

COURSE OUTCOMES

On successful completion of the course, students will be able to:
1. Understand all the important components such as PLC, SCADA, DCS, I/O modules and field devices of an industrial automation system. (L1, L2)
2. Develop PLC program in different languages for industrial applications. (L3)
3. Interface transmitters, final control elements and smart field devices with PLC and DCS. (L3)
4. Configure and develop Feedback Control Schemes using PLC and DCS. (L4)
5. Select and use most appropriate automation technologies for a given application. (L5)
6. Configure IoT gateway for any industrial process using DCS. (L4)
7. Develop ladder Logic/Functional Block Program for the Real time applications. (L6)

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	3	3	2	3	3	3	3	3	3	2	2	3
CO2	3	3	3	2	3	-	-	3	3	3	2	-	2	2	3
CO3	3	3	3	3	3	2	-	3	3	2	2	3	2	2	3
CO4	3	3	3	3	3	-	-	2	3	3	2	-	2	2	3
CO5	3	3	3	3	3	3	1	2	2	3	3	3	2	2	3
CO6	3	3	3	3	3	2	1	2	2	2	3	-	2	2	3
CO7	3	3	3	3	3	-	-	2	2	2	3	2	2	2	3
Avg	3	3	3	2.9	3	2.3	0.9	2.4	2.3	2.6	2.6	2.8	2	2	3

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23701 **SUMMER INTERNSHIP / MINI PROJECT**

L	T	P	C
0	0	0	2

COURSE OBJECTIVES:

•

The student should undergo Internship for a minimum period of 4 weeks/ maximum 6 weeks in industry/Research organization / academic institution. The student earns 2 credits by undergoing the Internship. Internship needs to be undergone continuously in one organization only. The student is allowed to undergo a maximum of 6 weeks Internship at the end of sixth semester during the summer vacation. The Internship shall carry 100 marks. The review committee may be constituted by the Head of the Department. At the end of Internship, the student shall submit a brief report on the training undergone and a certificate from the organization concerned. The evaluation will be made based on this report and a viva-voce Examination, conducted internally by a three-member Departmental Committee constituted by the Head of the Department.

TOTAL : 240 PERIODS

COURSE OUTCOMES:

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

1. Find solution for complex engineering problems applying the engineering knowledge.
2. Prepare a good technical report and able to present the ideas with clarity.
3. Gain Knowledge on various terminologies related to industrial environment.
4. Able to work efficiently as a member of different teams related to multidisciplinary projects
5. Acquire skills to communicate efficiently and gain management skills related to industry / research organizations.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	3	-	-	3	-	-	3	3	3	3	3
CO2	3	3	3	3	3	-	-	3	-	-	3	3	3	3	3
CO3	3	3	3	3	3	-	-	3	-	-	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	-	3	3	3	3	3
CO5	3	3	3	3	3	-	-	3	3	-	3	3	3	3	3
Avg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23801 PROJECT WORK/SEMESTER LONG INTERNSHIP

L	T	P	C
0	0	16	8

COURSE OBJECTIVES:

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The aim of the project work is to deepen Comprehension of principles by applying them to a new problem which may be the design /fabrication of Sensor/Activator/Controller, a research investigation, a computer or management project or a design problem.

The progress of the project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department.

A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

Note: In the case of industrial projects, the marks allotted for supervisor will be shared equally by the supervisor from the Department and coordinator from Industry..

TOTAL : 240 PERIODS

COURSE OUTCOMES:

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

1. Find solution for complex engineering problems applying the engineering knowledge. (L1)
2. Formulate and analyze complex engineering problem. (L4, L5)
3. Select and apply software tools required to solve the formulated problem. (L3)
4. Identify and find solution to societal issues and work as a member in a team. (L3)
5. Build solutions to the formulated problem using multidisciplinary engineering knowledge. (L6)
6. Communicate the engineering activity and to do effective documentation of the workcarried out. (L2)
7. Use the knowledge obtained from project to engage in life -long learning. (L5)
8. Build solution for complex engineering problems applying the engineering knowledge. (L6)

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	3	-	-	3	-	-	3	3	3	3	3
CO2	3	3	3	3	3	-	-	3	-	-	3	3	3	3	3
CO3	3	3	3	3	3	-	-	3	-	-	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	-	3	3	3	3	3
CO5	3	3	3	3	3	-	-	3	3	-	3	3	3	3	3
CO6	3	3	3	3	3	-	-	3	3	-	3	3	3	3	3
CO7	3	3	3	3	3	-	-	3	-	3	3	3	3	3	3
CO8	3	3	3	3	3	-	-	3	-	3	-	3	-	-	-
Avg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

1-Low, 2-Medium, 3-High, '-"- no correlation

VERTICAL I - INDUSTRIAL AUTOMATION

EI23001	**POWER ELECTRONICS DRIVES AND CONTROL**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT – I POWER SEMICONDUCTOR DEVICES AND CHARACTERISTICS 9L

Operating principle and switching Characteristics: Power diodes - Power BJT, Power MOSFET, IGBT, SCR, GTO, Power integrated circuits (PIC) – Drive and Protection circuits – Series and parallel operations–Commutation.

UNIT – II CONTROLLED RECTIFIERS AND AC CONTROLLERS 9L

Single phase – Three phase – Half controlled – Fully controlled rectifiers – Dual converters -Effect of source and load inductance - AC voltage controllers –Introduction to Cyclo converters, Matrix converters-analysis with simulation tools.

UNIT – III DC TO DC CONVERTERS 9L

Step up and Step-down Chopper – Chopper classification - quadrant of operation – Switching mode Regulators – Buck, Boost, Buck-Boost, and Cuk Regulators- analysis with simulation tools.

UNIT – IV INVERTERS 9L

Voltage source Inverters –1-PhaseHalf bridge and Full bridge –3-Phase Bridge Inverters – Voltage control –PWM Techniques – Current Source Inverters - Resonant inverters: Series, Parallel, ZVS, ZCS –Introduction to multilevel Inverters- analysis with simulation tools.

UNIT – V DRIVES AND CONTROL 9L

Dynamics of motor-load system -Static and Dynamic equations of dc and ac (3-phase induction and synchronous motor) machines -State space model – Electrical breaking – Rectifier and chopper control of dc motors – Principle of v/f control of ac motors– Closed loop control of dc and ac drives (Block diagram approach only) – Introduction to vector control of ac drives.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain and analyse operations, characteristics and protection of power semiconductor devices (L1, L2).
2. Classify, analyze and design, Controlled rectifier and AC Controllers (L2, L4).
3. Classify, analyze and design of DC to DC converters and DC to AC converters (L2, L5).
4. Apply power electronic circuits for the control of electric drive applications (L3).
5. Design and analyze power electronic circuits using simulation software (L3).

REFERENCES:

1. Rashid, M.H., “Power Electronics – Circuits, Devices and Applications”, PHI, Fourth edition, 2014.

2. Mohan, Udeland and Robbins, “Power Electronics”, John Wiley and Sons, New York, 3rd edition 2006.
3. Daniel. W. Hart., “Power Electronics”, McGraw Hill Education India, 2011.
4. Bimbra, P.S., “Power Electronics”, Khanna Publishers, 5th edition, 2012.
5. Singh, M.D., and Khanchandani, K.B., “Power Electronics”, 2nd edition, Tata McGraw-Hill, 2017.
6. Bose, B.K., “Modern Power Electronics and AC Drives”, Pearson Education, 2002.
7. Moorthi, V.R., “Power Electronics - Devices, Circuits and Industrial Applications”, Oxford University Press, 2005

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	2	-	-	-	1	-	1	2	-	1	1
CO2	3	3	3	2	2	-	-	-	1	-	1	2	-	1	1
CO3	3	3	3	2	2	-	-	-	1	-	1	2	-	1	1
CO4	3	3	3	2	2	-	-	-	1	-	1	2	-	1	2
CO5	3	2	2	2	3	-	-	-	1	-	1	2	-	1	2
Avg.	3	2.8	2.8	2	2.2	-	-	-	1	-	1	2	-	1	1.3

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23002 **ROBOTICS AND AUTOMATION**

L	T	P	C
3	0	0	3

UNIT – I BASICS CONCEPTS 9L

Definition and origin of robotics – different types of robotics – various generations of robots – degrees of freedom – Robot classifications and specifications- Asimov's laws of robotics – dynamic stabilization of robots

UNIT – II POWER SOURCES, SENSORS AND ACTUATORS 9L

Hydraulic, pneumatic and electric drives: Design and control issues – determination of HP of motor and gearing ratio – variable speed arrangements – path determination – micro machines in robotics – machine vision – ranging – laser – acoustic – magnetic, fiber optic and tactile sensors.

UNIT – III MANIPULATORS AND GRIPPERS DIFFERENTIAL MOTION 9L

Construction of manipulators – manipulator dynamics and force control – electronic and pneumatic manipulator control circuits – end effectors – U various types of grippers – design considerations.

UNIT – IV KINEMATICS AND PATH PLANNING 9L

Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance Solution kinematics problem – robot programming languages.

UNIT – V DYNAMICS and CONTROL 9L

Lagrangian mechanics-2DOF Manipulator-Lagrange Euler Formulation-Dynamic model – Manipulator control problem-Linear control schemes - PID control scheme-Force control of robotic manipulator .Multiple robots – machine interface – robots in manufacturing and non-manufacturing applications – robot cell design – selection of robot – Cobots.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Kinds of sensors for industrial robot applications.
2. Familiarization with relevant software tool (MATLAB) and programming language
3. Controlling Arduino Robot using Android Smartphone
4. Real time robotics projects (Soccer robots, line follower etc.)
5. Socket Programming

COURSE OUTCOMES:

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

1. Understand the evolution of robot technology and mathematically represent different types of robots. (L2)
2. Get exposed to the case studies and design of robot machine interface. (L3)
3. Analyze various control schemes of Robotics control. (L4)
4. Ability to select appropriate configuration of rotor for a specific application. (L5)
5. Ability to choose actuator/sensor for robot. (L1)

REFERENCES:

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., Industrial Robotics, McGraw-Hill Singapore, 2015.
2. Saeed B Niku, Introduction to Robotics, Analysis, Systems, Applications Prentice Hall, 3rd edition 2104.
3. Deb.S.R., Robotics technology and flexible Automation, John Wiley, USA 2nd edition (2017)
4. Klafter R.D., Chimielewski T.A., Negin M., Robotic Engineering – An integrated approach, Prentice Hall of India, New Delhi, 1994.
5. R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint,2005
6. JohnJ.Craig ,Introduction to Robotics Mechanics and Control, Third edition, Pearson
7. Education, 2009.

List of Open-Source Software/ Learning website:

1. https://nptel.ac.in/courses/112105249
2. https://nptel.ac.in/courses/107106090
3. https://nptel.ac.in/courses/112101098
4. http://site.ieee.org/scv-css/files/2015/04/IEEE-Robotics-Talk.pdf
5. https://www.intel.com/content/www/us/en/robotics/types-and-applications.html
6. https://nitc.ac.in/app/webroot/img/upload/M4P3.pdf

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	1	1	-	-	-	-	-	-	-	-	3	-	-
CO2	3	2	2	2	-	-	-	-	-	-	-	-	3	-	-
CO3	3	3	3	2	-	-	-	-	-	-	-	-	3	-	-
CO4	3	3	3	2	-	-	-	-	-	-	-	-	3	-	-
CO5	3	3	3	2	-	-	-	-	-	-	-	-	3	-	-
Avg.	2.8	2.6	2.4	1.8	-	-	-	-	-	-	-	-	3	-	-

1-low, 2-medium, 3-high, '-" - no correlation

EI23003	SAFETY INSTRUMENTED SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

-

UNIT – I INTRODUCTION 9L

Safety Instrumented System (SIS): need, features, components, difference between basic process control system and SIS - Risk: how to measure risk, risk tolerance, Safety integrity level, safety instrumented functions - Standards and Regulation – HSE-PES, AICHE-CCPS, IEC-61508, ANSI/ISA-84.00.01-2004 (IEC 61511 Mod) & ANSI/ISA – 84.01-1996, NFPA 85, API RP 556, API RP 14C, OSHA (29 CFR 1910.119 – Process Safety Management of Highly Hazardous Chemicals – SIS design cycle - Process Control vs Safety Control.

UNIT – II PROTECTION LAYERS AND SAFETY REQUIREMENT SPECIFICATIONS 9L

Prevention Layers: Process Plant Design, Process Control System, Alarm Systems, Procedures, Shutdown/Interlock/Instrumented Systems (Safety Instrumented Systems – SIS), Physical Protection - Mitigation Layers: Containment Systems, Scrubbers and Flares, Fire and Gas (F&G) Systems, Evacuation Procedures - Safety specification requirements as per standards, causes for deviation from the standards.

UNIT – III SAFETY INTEGRITY LEVEL (SIL) 9L

Evaluating Risk, Safety Integrity Levels, SIL Determination Method: As Low As Reasonably Practical (ALARP), Risk matrix, Risk Graph, Layers Of Protection Analysis (LOPA) – Issues related to system size and complexity –Issues related to field device safety – Functional Testing

UNIT – IV SYSTEM EVALUATION 9L

Failure Modes, Safe/Dangerous Failures, Detected/Undetected Failures, Metrics: Failure Rate, MTBF, and Life, Degree of Modeling Accuracy, Modeling Methods: Reliability Block Diagrams, Fault Trees, Markov Models - Consequence analysis: Characterization of potential events, dispersion, impacts, occupancy considerations, consequence analysis tools - Quantitative layer of protection analysis: multiple initiating events, estimating initiating event frequencies and IPL failure probabilities.

UNIT – V CASE STUDY 9L

SIS Design check list - Case Description: Furnace/Fired Heater Safety Shutdown System: Scope of Analysis, Define Target SILs, Develop Safety Requirement Specification (SRS), SIS Conceptual Design, Lifecycle Cost Analysis, verify that the Conceptual Design Meets the SIL, Detailed Design, Installation, Commissioning and Pre-startup Tests, Operation and Maintenance Procedures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Analyse the role of safety instrumented system in the industry. (L4)
2. Define various hazards in industry environment. (L1)
3. Summarize the safety integrity level for an application. (L2)
4. Distinguish the safety environment in industry. (L2)

5. Analyse the failure modes, failure rates and MTBF using various reliability engineering tools. (L4)
6. Apply the design, installation and maintenance procedures for SIS applied to industrial processes. (L3)

REFERENCES:

1. Paul Gruhn and Harry L. Cheddie," Safety Instrumented Systems: Design, Analysis and Justification", ISA, 2nd edition, 2018.
2. Eric W. Scharpf, Heidi J. Hartmann, Harlod W. Thomas, "Practical SIL target selection: Risk analysis per the IEC 61511 safety Lifecycle", exida2nd Edition 2022.
3. William M. Goble and Harry Cheddie, "Safety Instrumented Systems Verification: Practical Probabilistic Calculations" ISA, 2012.
4. Edward Marszal, Eric W. Scharpf, "Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis", ISA, 2002.
5. Standard - ANSI/ISA-84.00.01-2004 Part 1 (IEC 61511-1 Mod) "Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Software Requirements", ISA, 2004

List of Open-Source Software/ Learning website:

1. http://nptel.iitm.ac.in/courses.php
2. https://nptel.ac.in/courses/110105094
3. https://nptel.ac.in/courses/110105160
4. https://nptel.ac.in/courses/112106177
5. https://www.exida.com/Blog/back-to-basics-04-safety-instrumented-system-sis
6. http://nptel.iitm.ac.in/courses.php

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	-	-	-	1	-	1	-	-	3	3	2
CO2	1	1	1	1	-	-	-	1	-	1	-	-	3	2	3
CO3	2	2	1	2	-	-	-	1	-	1	-	-	3	3	2
CO4	2	1	2	1	-	-	-	1	-	1	-	-	2	2	1
CO5	3	3	3	2	-	-	-	1	-	1	-	-	3	3	2
CO6	3	2	2	2	-	-	-	1	-	1	-	-	3	3	-
Avg.	2.33	2	2	1.66	-	-	-	1	-	1	-	-	2.83	2.66	2

1-low, 2-medium, 3-high, '-" - no correlation

EI23004	IoT FOR INDUSTRIAL AUTOMATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

-

UNIT – I INTERNET PRINCIPLES AND IoT FUNDAMENTALS 9L

Networking Principles: ISO/OSI model, TCP/IP stack, TCP and UDP, MAC address and IP address, IPv4 and IPv6, Static and dynamic addressing, Domain Name System - IoT Fundamentals: Emergence and Evolution, Enabling technologies , Application domains, Functional blocks of IoT Systems.

UNIT – II IoT PROTOCOLS 9L

Physical and MAC layers: IEEE 802.15.4 - ZigBee, ISA100.11a, Wireless HART -1901.2a - 802.11ah - LoRaWAN - Network Layer: Constrained Nodes and Constrained Networks – Optimizing IP for IoT: 6LoWPAN and 6Lo - Routing over Low Power and Lossy Networks - Application Layer: MQTT and CoAP.

UNIT – III DATA ANALYTICS FOR IOT 9L

Big data Analytics: Structured and unstructured data - Data in motion and at rest - IoT Data Analytics overview - IoT Data Analytics Challenges - Big data analytics tools and technology: Massively Parallel Processing Databases, NoSQL Databases, Hadoop - Edge Streaming Analytics - Network Analytics - Visualization and power tools.

UNIT – IV IoT APPLICATIONS IN MANUFACTURING INDUSTRIES 9L

Introduction to connected manufacturing - IoT Strategy for connected manufacturing - Architecture for the connected factory - Industrial automation and control systems reference model - CPwE reference model - CPwE wireless - Connected factory security.

UNIT – V IoT APPLICATIONS IN OIL AND GAS INDUSTRIES 9L

The oil and gas value chain - Role of IoT and digitization in oil and gas industry - Oil and gas use cases for IoT - Risk control framework for cybersecurity - The oil and gas process control network security use cases.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Infer the concept of IoT and acquire adequate knowledge over computer networking. (L2)
2. Choose appropriate protocols for a given IoT application. (L3)
3. Infer the concept of data analytics and understand the nuances of various data analytics tools. (L2)
4. Construct IoT ecosystem for manufacturing plants. (L3)
5. Provide IoT enablement to oil and gas industry. (L3)
6. Investigate the need and provide IoT solutions for industrial applications. (L4)

REFERENCES:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, —IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things, Cisco Press, 2017.

2. Greg Dunko, Joydeep Misra, Josh Robertson and Tom Snyder, "A Reference Guide to the Internet of Things", Bridgera LLC, 2017.
3. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
4. Olivier Hersent, David Boswarthick, Omar Elloumi , "The Internet of Things – Key applications and Protocols", Wiley, 2012

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	1	-	-	-	1	-	1	-	3	-	1	1
CO2	3	1	3	1	2	-	-	1	-	1	-	3	-	1	1
CO3	3	3	3	2	3	-	-	1	-	1	-	3	-	-	1
CO4	3	3	3	3	3	2	2	1	2	2	1	3	1	1	3
CO5	3	3	3	3	3	2	2	1	2	2	1	3	1	1	3
CO6	3	3	3	3	3	2	2	1	2	2	1	3	1	3	3
Avg.	**3**	**2.7**	**2.8**	**2.2**	**2.8**	**2**	**2**	**1**	**2**	**1.5**	**1**	**3**	**1**	**1.4**	**2**

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23005	IoT SYSTEM DESIGN	L	T	P	C
		3	0	0	3

UNIT – I INTRODUCTION 9L

IoT Fundamentals: Definition and Characteristics, Physical Design of IoT, Logical Design of IoT, Levels of IoT Deployment - IoT communication models - IoT Communication APIs - IoT Application Domains.

UNIT – II IoT ENABLING TECHNIQUES 9L

Wireless Sensor Networks: Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes - Embedded Systems: Selection of processors, Embedded programming, Open source platforms - Computing Strategies: Edge, fog and cloud computing - Big data analytics: Structured and unstructured data - Data in motion and at rest - IoT Data Analytics overview - IoT Data Analytics Challenges.

UNIT – III IoT PROTOCOLS 9L

IoT Accessing Technologies: IEEE 802.15.4, ZigBee, Z Wave, BLE, NFC, Thread, LoRaWAN - Constrained Nodes and Constrained Networks - 6LoWPAN and 6Lo - MQTT and CoAP.

UNIT – IV IoT SYSTEM DEVELOPMENT 9L

IoT gateways - IoT middleware platforms – IoT application development using Arduino/Raspberry Pi - IoT device management - IoT device security.

UNIT – V IoT USE CASES 9L

Smart lighting - Smart water management - Environment monitoring - Process monitoring - Precision farming.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Discussion/Content Preparation/Seminar/Quiz/Mini Project/)

1. Selection of appropriate embedded processor with associated peripherals for IoT applications.
2. Familiarity with open-source platforms pertaining to IoT technology.
3. Development of embedded solutions for IoT applications.
4. Building IoT solutions for the use cases involved in the study.

COURSE OUTCOMES:

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

1. Infer the concept of IoT and its architectural features. (L2)
2. Articulate the role of key technologies that enable the concept of IoT. (L2)
3. Choose appropriate protocols for a given IoT application. (L3)
4. Design IoT enabled embedded systems using necessary hardware and software tools. (L3)
5. Build IoT architecture for given applications. (L3)
6. Investigate the need and provide IoT solutions for various IoT application domains. (L4)

REFERENCES:

1. ArshdeepBahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
2. Perry Lea, "Internet of things for architects", Packt, 2018.
3. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things", Cisco Press, 2017.
4. Olivier Hersent, David Boswarthick, Omar Elloumi , "The Internet of Things – Key applications and Protocols", Wiley, 2012

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	1	-	-	-	1	-	1	-	3	-	1	1
CO2	3	3	1	2	2	-	-	1	-	1	-	-	-	3	1
CO3	3	1	3	1	2	-	-	1	-	1	-	3	-	1	1
CO4	3	3	3	3	3	2	2	1	-	2	2	3	1	3	1
CO5	3	3	3	3	3	2	2	1	-	2	2	3	1	1	3
CO6	3	3	3	3	3	2	2	1	2	2	1	3	1	3	3
Avg.	**3**	**2.6**	**2.5**	**2.1**	**2.6**	**2**	**2**	**1**	**2**	**1.5**	**1.6**	**3**	**1**	**1.5**	**1.6**

1-low, 2-medium, 3-high, '-" - no correlation

EI23006 **DEEP LEARNING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

-

UNIT – I MACHINE LEARNING BASICS 9L

Learning algorithms, Maximum likelihood estimation, Building machine learning algorithm, Neural Networks Multilayer Perceptron, Back-propagation algorithm and its variants Stochastic gradient decent, Curse of Dimensionality.

UNIT – II INTRODUCTION TO DEEP LEARNING & ARCHITECTURES 9L

Machine Learning Vs. Deep Learning, Representation Learning, Width Vs. Depth of Neural Networks, Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Restricted Boltzmann Machines, Auto Encoders.

UNIT – III CONVOLUTIONAL NEURAL NETWORKS 9L

Architectural Overview – Motivation - Layers – Filters – Parameter sharing – Regularization, Popular CNN Architectures: ResNet, AlexNet – Case studies.

UNIT – IV EQUENCE MODELLING – RECURRENT AND RECURSIVE NETS 9L

Recurrent Neural Networks, Bidirectional RNNs – Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short Term Memory Networks – Case studies.

UNIT – V AUTO ENCODERS AND DEEP GENERATIVE MODELS 9L

Deep Belief networks – Boltzmann Machines – Deep Boltzmann Machine - Generative AdversialNetworks – Case studies.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Fundamentals of machine learning
2. Fundamentals of deep learning
3. Realization and understanding of CNN
4. Time series forecasting for data
5. Generating of synthetic images

COURSE OUTCOMES:

Students will be able to

1. Have a good understanding of the fundamental issues and basics of machine learning. (L2)
2. Ability to differentiate the concept of machine learning with deep learning techniques. (L4)
3. Understand the concept of CNN and transfer learning techniques, to apply it in classification problems. (L2)
4. Learned to use RNN for language modelling and time series prediction. (L3)
   Use autoencoder and deep generative models to solve problems with high dimensional data including text, image and speech. (L3)

REFERENCES:

1. Umberto Michelucci “Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks” Apress, 2018.

2. Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012.
3. Ethem Alpaydin,"Introduction to Machine Learning”, MIT Press, Prentice Hall of India, Third Edition 2014.
   Giancarlo Zaccone, Md. Rezaul Karim, Ahmed Menshawy "Deep Learning with TensorFlow: Explore neural networks with Python", Packt Publisher, 2017.

List of Open Source Software/ Learning website:

1. https://www.techtarget.com/searchenterpriseai/definition/machine-learning-ML
2. https://www.techtarget.com/searchenterpriseai/definition/deep-learning-deep-neural-network
3. https://www.simplilearn.com/tutorials/deep-learning-tutorial/rnn
4. https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	1	1	1	-	-	-	1	-	1	-	1	-	-	-
CO2	3	3	3	2	-	-	-	1	-	1	-	1	-	-	-
CO3	2	1	1	1	-	-	-	1	-	1	-	1	-	-	-
CO4	3	2	2	2	-	-	-	1	-	1	-	1	-	-	-
CO5	3	2	2	2	-	-	-	1	-	1	-	1	-	-	-
Avg	2.6	1.8	1.8	1.6	-	-	-	1.0	-	1.0	-	1.0	-	-	-

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23007 CYBER SECURITY FOR INDUSTRIAL AUTOMATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

•

UNIT – I INTRODUCTION 9L

Industrial security environment-Industrial automation and control system (IACS) culture Vs IT Paradigms- Cyber attacks: Threat sources and steps to successful cyber attacks. Impact of cyber security breach in manufacturing.

UNIT – II RISK ANALYSIS 9L

Risk identification, classification and assessment, Addressing risk: Cyber security Management System (CSMS), organizational security, physical and environmental security, network segmentation, access control, risk management and implementation.

UNIT – III ACCESSING THE CYBERSECURITY OF IACS 9L

Identifying the scope of the IACS- generation of cyber security information-identification of vulnerabilities- risk assessment-evaluation of realistic threat scenarios- Gap assessment-capturing Ethernet traffic- documentation of assessment results.

UNIT – IV CYBERSECURITY DESIGN AND IMPLEMENTATION 9L

Cyber security lifecycle- conceptual design process- detailed design process- firewall design-remote access design- intrusion detection design.

UNIT – V TESTING AND MAINTENANCE 9L

Developing test plans- cyber security factory acceptance testing- site acceptance testing- network and application diagnostics and troubleshooting- cybersecurity audit procedure- IACS incident response.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Apply basis of science and engineering to understand Industrial security environment and cyber attacks. (L1)
2. Analyze and assess risks in the industrial environment. (L4)
3. Access the cyber security of IACS. (L5)
4. Design and implement cyber security. (L3)
5. Test and troubleshoot the industrial network security system. (L2)
6. Understand, investigate and explore feasible solution for a moderate industrial problem.(L1,L5)

REFERENCES:

1. Ronald L and Krutz, Industrial Automation and Control System Security Principles, ISA, 2013.
2. David J.Teumim, Network Security, Second edition, ISA, 2010.
3. Edward J.M. Colbert and Alexander Kott, Cyber-security of SCADA and other industrial control systems, Springer, 2016.
4. Perry S. Marshalland John S. Rinaldi, Industrial Ethernet, Second edition, ISA, 2004

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	-	-	-	-	-	-	1	-	1	-	-	-	-	-
CO2	3	3	-	-	-	-	-	1	-	1	-	-	-	-	3
CO3	3	3	-	-	-	-	-	1	-	1	-	-	-	-	3
CO4	3	-	3	-	3	-	-	1	-	1	-	-	-	-	3
CO5	3	-	3	-	-	-	-	1	-	1	-	3	-	-	3
CO6	3	-	3	3	-	-	-	1	-	1	-	3	-	-	3
Avg.	3	3	3	3	3	-	-	1	-	1	-	3	-	-	3

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23008 **RELIABILITY AND SAFETY ENGINEERING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

•

UNIT – I RELIABILITY **9L**

Reliability:- Definition and basic concepts - Reliability:- block diagrams, failure data, failure modes - reliability in terms of hazard rates and failure density function - Hazard models and 'bath-tub' curve - Applicability of Weibull distribution - Reliability calculation for series, parallel series systems. - Reliability calculation for K-out of M systems.

UNIT – II CONCEPTS OF REDUNDANCY AND MAINTENENCE 9L

Use of redundancy and system reliability improvement methods - Use of redundancy and system reliability improvement methods - Maintenance:-Objectives, types of maintenance, preventive, condition-based maintenance - Reliability centered maintenance - Terotechnology - Total Productive Maintenance (TPM). -Total Productive Maintenance (TPM).

UNIT – III MAINTAINABILITY 9L

Maintainability:- Definition, basic concepts - relationship between reliability, maintainability and availability - corrective maintenance time distributions - maintainability demonstration - Design considerations for maintainability - Availability and reliability relationship

UNIT – IV RELIABILITY TESTS 9L

life-testing - destructive and non-destructive tests - estimation of parameters for exponential and Weibull distributions, - component reliability.

UNIT – V SAFETY 9L

Safety: Causes of failure and unreliability - measurement and prediction of human reliability - human reliability and operator training - Safety margins in critical devices - Origins of consumerism - Product knowledge, product safety - product liability and product safety improvement program.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Define and explain basic reliability concepts, utilize reliability block diagrams, interpret failure data and modes, and calculate reliability for various systems
2. Analyze and Implement Redundancy and Maintenance Strategies
3. analyze corrective maintenance time distributions, demonstrate maintainability, and incorporate maintainability considerations in design processes
4. Estimate parameters for exponential and Weibull distributions, and determine component reliability through appropriate testing techniques.
5. Identify causes of failure and unreliability.
6. Integrate Reliability, Maintainability, and Safety for System Optimization

REFERENCES:

1. Verma, A. K., Ajit, S., & Karanki, D. R. (2010). Reliability and safety engineering (Vol. 43, pp.373-392). London: Springer.
2. Birolini, A. (2007). Reliability engineering (Vol. 5). Berlin: Springer.

3. Dhillon, B. S. (2017). Engineering systems reliability, safety, and maintenance: An integrated approach. CRC Press.
4. O'Connor, P., & Kleyner, A. (2012). Practical reliability engineering. John Wiley & Sons.
5. Cepin, M., & Bris, R. (2017). Safety and reliability. Theory and applications. CRC Press.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO3	-	3	3	2	3	-	2	-	-	-	-	-	3	-	-
CO4	-	2	3	3	-	2	2	-	2	-	2	2	3	-	-
CO5	-	2	3	3	-	2	2	-	2	2	2	2	3	-	-
CO6	-	3	3	3	-	2	2	2	2	2	2	2	3	-	-
Avg.	3	2.3	3	2.8	3	2	2	2	2	2	2	2	3	-	-

1-Low, 2-Medium, 3-High, ‘-“- no correlation

VERTICAL II – MODELLING AND SIMULATION

EI23009	MATHEMATICAL MODELLING AND SYSTEM ANALYSIS	L	T	P	C
		3	0	0	3

UNIT – I SYSTEMS AND PROCESSES **9L**

Systems and processes: Static and dynamic systems - Lumped and distributed systems - Conservative and Non-conservative systems - Time invariant and time variant systems – Linear and nonlinear systems – Reversible and irreversible process - Work, energy and power - Mathematical analogies.

UNIT – II INTRODUCTION TO MATHEMATICAL MODELLING 9L

Modelling techniques: White box models, Black box models, Grey box models, Assumptions and Approximations, Continuous and discrete models., Linear/Polynomial regression, Multiple regression, Mathematical modelling using dimensional analysis, Applications of mathematical models.

UNIT – III SYSTEM MODELLING USING ORDINARY DIFFERENTIAL EQUATIONS 9L

Types of ordinary differential equations: Linear and nonlinear ODE’s, Homogeneous and nonhomogeneous ODE’s, Autonomous and non-autonomous ODE’s., - Order of the differential equation, Modelling of exponential growth and decay, Modelling of oscillatory dynamics, Degrees of freedom. Modelling using material balance and energy balance - examples

UNIT – IV BLACK BOX MODELLING 9L

Experimental Design –Linear and nonlinear models for system identification, Parameter estimation methods: Least squares method, Recursive Least squares method, Maximum Likelihood estimation, Dynamic Programming.

UNIT – V SIMULATION AND ANALYSIS 9L

Solving Equations on the Computer: Euler's Method, Runge–Kutta method, Adams predictor corrector method. - Stability Analysis: Fixed points of a system, Phase Plane Analysis, Liapunov’s Direct Method

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Explain and compare various types of systems and processes.
2. Select appropriate modelling approaches for given problems.
3. Formulate mathematical models using first principles.
4. Develop mathematical models using experimental data.
5. Solve and analyze the developed models.
6. Develop models for engineering problems from a variety of settings in general mathematical forms

REFERENCES:

1. Giordano, F., Fox, W. P., & Horton, S. A first course in mathematical modeling. Nelson Education., 2013.
2. Kapur, J. N. Mathematical Modelling. New Age International., 1988.
3. Johansson, RSystem modeling & identification. Prentice-Hall.,1993.
4. Ljung, L. System identification. John Wiley & Sons, Inc.,1999. MODELLING AND SIMULATION LTPC3003 58
5. Andrews, J. G., & McLone, R. R. (Eds.) Mathematical modelling. London: Butterworths.,1976
6. Kamalanand, K., & Jawahar, P. Mathematical modelling of systems and analysis. PHI Learning Pvt. Ltd.,2018.
7. Butcher, J. C. Numerical methods for ordinary differential equations. John Wiley & Sons.,2016

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	2	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	1	2	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	1	2	3	-	-	-	-	-	-	-	-	-	-	-
CO4	3	1	2	3	-	-	-	-	-	-	-	-	-	-	-
CO5	3	1	2	3	-	-	-	-	-	-	-	-	-	-	-
CO6	3	1	2	3	-	-	-	-	-	-	-	-	-	-	-
Avg.	3	1	2	3	-	-	-	-	-	-	-	-	-	-	-

1 - low, 2-medium, 3-high, '-"- no correlation

EI23010 **PROCESS MODELLING AND SIMULATION**

L	T	P	C
3	0	0	3

UNIT – I GENERAL PRINCIPLES OF MODELLING **9L**

Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models: Linear vs Nonlinear, Lumped parameter vs. Distributed parameter; Static vs. Dynamic, Continuous vs. Discrete; Numerical Methods: Iterative convergence methods, Numerical integration of ODE- IVP and ODEBVP

UNIT – II MODELLING OF DISTRIBUTED PROCESSES 9L

Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based Approaches for staged processes; Modeling of differential contactors – distributed parameter models of packed beds; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries.

UNIT – III INTRODUCTION TO PROCESS MODELLING 9L

Concept of degree of freedom analysis: System and its subsystem, System interaction, Degree of freedom in a system e.g., Heat exchanger, Equilibrium still, Reversal of information flow, Design variable selection algorithm, Information flow through subsystems, Structural effects of design variable selection, Persistent Recycle

UNIT – IV MODELLING OF INDUSTRIAL PROCESSES 9L

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, -steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc.; Review of solution procedures and available numerical software libraries.

UNIT – V SIMULATION OF MATHEMATICAL MODELS 9L

Simulation and their approaches, Modular, Sequential, Simultaneous and Equation solving approach, Simulation tools and their applications, Review of solution techniques and available numerical software libraries - Case Studies.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/ContentPreparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Developing steady state /Dynamic mathematical model of different unit processes (ODE or PDE)
2. Simulation of steady state/ dynamic models using appropriate software
3. Open loop study based on the developed mathematical model.
4. Development and simulation of unsteady state models for simple processes.

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Understand different methods of developing models for industrial processes. (L1)

2. Build mathematical models by applying relevant mathematics. (L3)
3. Implement mathematical models using relevant software. (L4)
4. Effectively perform analysis and subsequent conclusion for the developed mathematical models. (L5)
5. Interpret the results obtained from the mathematical model in terms of original real-world problem. (L2)

REFERENCES:

1. Denn M. M., "Process Modeling", Longman, 1986
2. Aris R., "Mathematical Modeling, A Chemical Engineering Perspective (Process System Engineering)", Academic Press, 1999.
3. Luyben W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, McGraw Hill.
4. D. F. Rudd and C. C. Watson, “Strategy of Process Engineering”, Wiley international.
5. M.M. Denn, “Process Modelling”, Wiley, New York,
6. A. K. Jana, “Chemical Process Modelling and Computer Simulation”, PHI
7. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall,
8. Hussain Asghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi,

List of Open-Source Software/ Learning website:

1. https://archive.nptel.ac.in/courses/103/107/103107096/
2. https://nptel.ac.in/courses/103101111
3. https://nptel.ac.in/courses/111107105
4. https://www.academia.edu/37228967/Process_Modeling_Simulation_and_Control_for_Chemical_Engineers

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	-	-	2	-	-	-	-	-	-	-	-	-	3
CO2	3	1	2	-		-	-	-	-	-	-	-	-	-	3
CO3	1	-	2	3	3	-	-	-	-	-	-	-	-	-	3
CO4	1	-	3	-	-	-	2	-	-	-	-	-	-	-	3
CO5	1	2	-	3	-	-	-	-	-	-	-	-	-	-	3
Avg.	1.8	1.3	2.3	3	2.5	-	2	-	-	-	-	-	-	-	3

1-low, 2-medium, 3-high, ‘-“- no correlation

EI23011 **VIRTUAL INSTRUMENTATION**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION 9L

Virtual Instrumentation – Definition and Flexibility – Block diagram and Architecture of Virtual Instruments – Virtual Instruments versus Traditional Instruments – Review of software in Virtual Instrumentation – VI programming techniques - VI, sub VI, Loops and Charts, Arrays, Clusters and Graphs, Case and Sequence Structures, Formula nodes, String and File Input/Output.

UNIT – II DATA ACQUISITION IN 9L

A/D and D/A Converters, plug-in Analog Input/Output cards - Digital Input and Output Cards, Organization of the DAQ VI system - Opto Isolation – Performing analog input and analog output - Scanning multiple analog channels - Issues involved in selection of Data acquisition cards - Data acquisition modules with serial communication - Design of digital voltmeters with transducer input – Timers and Counters .

UNIT – III COMMUNICATION NETWORKED MODULES 9L

Introduction to PC Buses – Local busses:- ISA, PCI, RS232, RS422 and RS485 – Interface Buses:- USB, PCMCIA, VXI, SCXI and PXI -Instrumentation Buses :- Modbus and GPIB - Networked busses – ISO/OSI Reference model, Ethernet and TCP / IP Protocols.

UNIT – IV REAL TIME CONTROL IN VI 9L

Design of ON/OFF controller and Proportional controller for a mathematically described Zrocesses using VI software – Modeling and basic control of Level and Reactor Processes – Case studies on development of HMI, SCADA in VI.

UNIT – V APPLICATIONS 9L

PC based digital storage oscilloscope - Sensor Technology and Signal Processing - Virtual Laboratory - Spectrum Analyser - Waveform Generator – Data visualization from multiple locations:- Distributed monitoring and control - Vision and Motion Control.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Understand the fundamental concepts and methods of Virtual Instrumentation.
2. 2Develop proficiency in VI programming techniques.
3. Implement data acquisition systems using A/D and D/A converters, digital input/output cards, and DAQ modules, and design digital voltmeters with transducer inputs.
4. Design and implement real-time control systems using VI software for various processes, including ON/OFF and proportional controllers for process control applications.
5. Apply virtual instrumentation techniques in practical applications such as PC-based digital storage oscilloscopes, sensor technology and signal processing, virtual laboratories, spectrum analyzers, and waveform generators

REFERENCES:

1. Nadovich, C., “Synthetic Instruments Concepts and Applications”, Elsevier, 2005.

2. Bitter, R., Mohiuddin, T. and Nawrocki, M., “Labview Advanced Programming Techniques”, CRC Press, 2nd Edition, 2007.
3. Gupta, S. and Gupta, J. P., “PC Interfacing for Data Acquisition and Process Control”, 2nd Edition, Instrument Society of America, 1994.
4. Jamal, R. and Picklik, H., “Labview – Applications and Solutions”,National Instruments Release.
5. Johnson, G., “Labview Graphical programming”, McGraw-Hill, Newyork, 1997.
6. Wells, L.K. and Travis, J., “Labview for Everyone”, Prentice Hall, NewJersey, 1997.
7. Buchanan, W., “Computer Busses”, CRC Press, 2000.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	1	-	-	2	-	-	-	-	-	-	-	2	-	3
CO2	3	1	2	-		-	-	-	-	-	-	-	-	-	3
CO3	1	-	2	3	3	-	-	-	2	-	-	-	2	-	3
CO4	1	-	3	-	-	-	2	-	-	-	-	-	-	-	3
CO5	1	2	-	3	-	-	-	-	2	-	-	-	2	-	3
CO6	1.8	1.3	2.3	3	2.5	-	2	-	-	-	-	-	-	-	3
Avg.	3	1	-	-	2	-	-	-	2	-	-	-	2	-	3

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23012 **SYSTEM IDENTIFICATION**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION 9L

Dynamic systems, Models for Linear Time-invariant Systems, time varying systems and nonlinear systems, The system identification procedure, Non-parametric methods- Transient analysis, Frequency analysis, correlation analysis and spectral analysis.

UNIT – II PARAMETER ESTIMATION METHODS 9L

Least square estimation – best linear unbiased estimation under linear constraints – updating the parameter estimates for linear regression models – prediction error methods: description of prediction methods – optimal prediction – relation between prediction error methods and other identification methods – theoretical analysis -Instrumental variable methods: Description of instrumental variable methods – Inputsignal design for identification

UNIT – III RECURSIVE IDENTIFICATION METHODS 9L

The recursive least square method – the recursive instrumental variable methods- the recursive prediction error methods – Maximum likelihood.

UNIT – IV CLOSED- LOOP IDENTIFICATION 9L

Identification of systems operating in closed loop: Identifiability considerations – direct identification – indirect identification – joint input / output identification - Subspace methods for estimating state space models.

UNIT – V PRACTICAL ASPECTS OF IDENTIFICATION 9L

Practical aspects: experimental conditions – drifts and de-trending – outliers and missing data – pre-filtering -robustness – Model validation and Model structure determination- case studies – Introduction to Nonlinear System Identification- Introduction to Control relevant System Identification.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Understand and differentiate between dynamic system models, including linear time-invariant systems, time-varying systems, and nonlinear systems,
2. Apply the system identification procedure using non-parametric methods such as transient, frequency, correlation, and spectral analysis.
3. Apply parameter estimation methods, including least square estimation, best linear unbiased estimation, and prediction error methods
4. Identify systems operating in closed-loop conditions using direct and indirect methods.
5. Address practical aspects of system identification, including dealing with experimental conditions, data issues, model validation, and model structure determination.

REFERENCES:

1. Soderstorm T and Peter Stoica, System Identification, Prentice Hall International,1989.
2. Ljung L, System Identification: Theory for the user, Prentice Hall, Englewood Cliffs, 1987.
3. E. Ikonen and K. Najim, “ Advanced Process Identification and Control”, Marcel Dekker, Inc. Newyork, 2002.

4. Keesman, K. J. (2011). System identification: an introduction. Springer Science & Business Media.
5. Nelles, O., & Nelles, O. (2020). Nonlinear dynamic system identification (pp. 831-891). Springer International Publishing.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	-	-	2	-	-	-	-	2	-	-	3	-	-
CO2	3	1	2	-		-	-	-	2	-	-	-	3	-	-
CO3	1	-	2	3	2	-	-	-	-	2	-	-	3	-	-
CO4	1	-	2	-	-	-	2	-	-	-	-	-	3	-	-
CO5	1	2	-	3	-	-	-	-	2	2	-	-	3	-	-
CO6	1.8	1.3	2	3	2	-	2	-	-	-	-	-	3	-	-
Avg.	3	1	2	-	2	-	-	-	2	2	-	-	3	-	-

1 - low, 2-medium, 3-high, '-"- no correlation

EI23013 **STATE AND PARAMETER ESTIMATION**

L	T	P	C
3	0	0	3

UNIT – I KALMAN UPDATE BASED FILTERS & PARTICLE FILTER 9L

Review of Matrix Algebra and Matrix Calculus and Probability Theory – Least SquareEstimation – Kalman filter – Extended Kalman filter – Unscented Kalman filter – Ensemble Kalman filter – Particle filter.

UNIT – II PARAMETER ESTIMATION METHODS 9L

Parametric model structures: ARX, ARMAX, OE, BJ models - Least squares method, Weighted Least Squares, Maximum Likelihood Estimation and Prediction error methods. Recursive Estimation methods – Simultaneous State and Parameter Estimation – Dual State and Parameter Estimation.

UNIT – III CLOSED- LOOP IDENTIFICATION 9L

Identification of systems operating in closed loop: direct identification and indirect identification – Subspace Identification methods: classical and innovation forms – Relay feedback identification of stable processes.

UNIT – IV NONLINEAR SYSTEM IDENTIFICATION 9L

Modeling of non linear systems using ANN- NARX & NARMAX - Training Feed-forward and Recurrent Neural Networks – TSK model – Adaptive Neuro-Fuzzy Inference System (ANFIS) - Introduction to Support Vector Regression.

UNIT – V PRACTICAL ASPECTS OF IDENTIFICATION 9L

Practical aspects: experimental design – input design for identification, notion for persistent excitation, drifts and de-trending – outliers and missing data – pre-filtering – robustness – Model validation and Model structure determination – Case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Ability to design and implement state estimation schemes.
2. Ability to develop various models (Linear & Nonlinear) from the experimental data.
3. Be able to select a suitable model and parameter estimation algorithm for the identification of systems.
4. Be able to carry out the verification and validation of identified model.
5. Will gain expertise on using the model for prediction and simulation purposes and for developing suitable control schemes.

REFERENCES:

1. Dan Simon, "Optimal State Estimation Kalman, H-infinity and Non-linear Approaches"John Wiley and Sons, 2006.
2. Lennart Ljung, "System Identification: Theory for the user", 2nd Edition, Prentice Hall, 1999.
3. Tangirala, A.K., "Principles of System Identification: Theory and Practice", CRC Press, 2014
4. Van der Heijden, F., Duin, R.P.W., De Ridder, D., and Tax, D.M.J., "Classification, Parameter Estimation and State Estimation", An Engineering Approach Using MATLAB, John Wiley & Sons Ltd., 2004.

5. Miller, W.T., Sutton, R.S., and Webrose, P.J., "Neural Networks for Control", MIT Press,1996.
6. Cortes, C., and Vapnik, V., "Support-Vector Networks, Machine Learning", 1995.
7. Karel J. Keesman, "System Identification an Introduction", Springer, 2011.
8. Tao Liu and Furong Gao, "Industrial Process Identification and control design, Step-test and relay-experiment-based methods", Springer- Verlag London Ltd., 2012

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	3	2	2	1	-	1	1	2	1	3	2	-	3
CO2	3	2	2	3	2	1	-	1	1	2	1	3	2	-	3
CO3	2	2	3	3	2	1	-	1	1	2	1	3	2	-	3
CO4	2	2	2	2	3	1	-	1	1	2	1	2	2	-	3
CO5	2	3	2	2	2	1	-	1	1	2	1	2	2	-	3
Avg.	2.2	2.2	2.4	2.4	2.2	1	-	1	1	2	1	2.6	2	-	3

1 - low, 2-medium, 3-high, '-"- no correlation

EI23014	OPTIMIZATION TECHNIQUES	L	T	P	C
		3	0	0	3

UNIT – I INTRODUCTION 9L

Historical Development, Engineering application of Optimization, Formulation of design problems as mathematical programming problems, classification of optimization problems.– Case studies

UNIT – II LINEAR PROGRAMMING 9L

Graphical method, Simplex method, Revised simplex method, Duality in linear programming (LP), Transportation, assignment and other applications.

UNIT – III NON LINEAR PROGRAMMING 9L

Unconstrained optimization techniques, Direct search methods, Descent methods, Constrained optimization, Direct and indirect methods, Optimization with calculus, Khun-Tucker conditions.

UNIT – IV DYNAMIC PROGRAMMING 9L

Introduction, Sequential optimization, computational procedure, curse of dimensionality, Applications in Control Engineering

UNIT – V ADVANCED TECHNIQUES OF OPTIMIZATION 9L

Introduction- Genetic algorithms for optimization and search – Multi-objective evolutionary optimization - The role of Pareto - optimal problems in Engineering Design and their solution Strategies based upon Genetic Algorithms – Usage in process control- Particle Swarm Optimization

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Understand of the engineering applications, and formulation of optimization problems as mathematical programming problems.
2. Apply linear programming techniques, including the graphical method, simplex method, revised simplex method, and duality, to solve transportation, assignment, and other optimization problems.
3. Utilize various unconstrained and constrained nonlinear programming techniques, including direct search methods, descent methods, and optimization with calculus, to solve complex optimization problems.
4. Implement dynamic programming methods, including sequential optimization and computational procedures, to address optimization issues in control engineering.
5. Solve different classes of optimization algorithms using appropriate techniques and select suitable optimization algorithms for specific engineering applications.

REFERENCES:

1. S.S. Rao, “Engineering Optimization: Theory and Practice”, New Age International (P) Ltd., New Delhi, 2000.
2. Diwekar, U. M. (2020). Introduction to applied optimization (Vol. 22). Springer Nature.
3. K. Deb, “Optimization for Engineering Design – Algorithms and Examples”,Prentice- Hall of India Pvt. Ltd., New Delhi, 5th Edition, 2004.

4. K. Deb, “Multi-Objective Optimization Using Evolutionary Algorithms”, John Wiley & Sons (ASIA) Private Ltd. Singapore, 2004.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	-	-	-	2	-	-	-	-	2	-	-	-	-	2	-
CO2	-	2	-	-	-	2	-	-	2	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO4	-	2	-	-	-	2	-	-	2	-	-	-	-	2	-
CO5	-	-	-	2	-	-	-	-	2	-	-	-	-	2	-
CO6	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-
Avg.	-	2	-	2	-	2	-	-	2	-	-	-	-	2	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

VERTICAL III - ADVANCED CONTROL

EI23C01	ADVANCED TOPICS IN PID CONTROL	L	T	P	C
		3	0	0	3

UNIT – I INTRODUCTION **9L**

Evolution of PID controller – PID Controller Structures – PID Implementation Issues – Tuning of PID Controller using Classical Approaches.

UNIT – II PID CONTROLLER DESIGN 9L

PID Controller Design Techniques: Pole placement, Lambda Tuning, Direct Synthesis, Gain Margin & Phase Margin and Optimization methods - Auto-Tuning.

UNIT – III PID STABILIZATION 9L

Stabilization of Linear Time-invariant Plants using P/PI/ PID controllers – Optimal Design using PID Controllers – Robust and Non-fragile PID Controller Design.

UNIT – IV ADAPTIVE/NON-LINEAR PID CONTROL SCHEMES 9L

Gain Scheduled PID Controller - Self-tuning PI/PID Controller – PID Types Fuzzy Logic Controller – Predictive PID Control.

UNIT – V INTRODUCTION TO FRACTIONAL ORDER SYSTEM AND FRACTIONAL ORDER PID CONTROLLER 9L

Fractional-order Calculus and Its Computations – Frequency and Time Domain Analysis of Fractional- Order Systems - Filter Approximations to Fractional-Order Differentiations –Model reduction Techniques for Fractional Order Systems – Fractional Order PI/PID Controller Design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Determine the advanced features supported by the Industrial Type PID Controller. (L1, L2)
2. Design & implement a P/PI/PID Controllers for a given process and validate through simulations. (L2, L3)
3. Design and implement optimal/ robust PID controller for a given process and validate through simulations. (L2, L3)
4. Design and implement adaptive PID controllers and PID types Fuzzy Logic Controller for a given process and validate through simulations. (L2, L3)
5. Analyze fractional-order systems, fractional-order- controller and design a suitable fractional order P/PI/PID controller for fractional order and Integer order systems. (L4)
6. Analyze various PID control schemes and recommend the right control strategy for a given application in accordance with the industrial requirement. (L5)

REFERENCES:

1. Karl J. Astrom and Tore Haggland, “Advanced PID Control”, ISA Publications, 2005.
2. Aniruddha Datta, Ming-Tzu Ho, and Shankar P.Bhattacharyya,“Structure and Synthesis of PID Controllers”, Advances in Industrial Control, Springer Verlag London, 2000.
3. Antonio Visioli, “Practical PID Control” Springer- Verlag London, 2006

4. Aidan O' Dwyer, “Handbook of PI and PID Controller Tuning Rules”, Imperial College Press, 2009
5. Xue, D., Chen, Y.Q., and Atherton, D.P., "Linear Feedback Control Analysis and Design with MATLAB, Advances in Design and Control", Society for Industrial and Applied Mathematics, 2008.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	-	-	-	-	-	-	1	3	2	-	2	-	3	3
CO2	3	-	3	-	3	-	-	1	3	2	-	2	3	3	3
CO3	3	-	3	-	3	-	-	1	3	2	-	1	-	3	3
CO4	3	-	3	-	3	-	-	1	3	2	-	1	3	3	3
CO5	3	3	3	3	3	-	-	1	3	2	-	1	3	3	3
CO6	3	-	-	3	-	-	-	1	-	-	-	-	-	-	3
Avg.	3	3	3	3	3	-	-	1	3	2	-	1.4	3	3	3

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23015 **COMPUTER CONTROL OF PROCESSES**

L	T	P	C
3	0	0	3

UNIT – I DISCRETE STATE-VARIABLE TECHNIQUE 9L

State equation of discrete time system with sample and hold – State transition equation – Methods of computing the state transition matrix – Decomposition of discrete time transfer functions – State diagram representations of Discrete time systems - Controllability and observability of linear time invariant discrete time system – Stability tests of discrete time system – State Observer.

UNIT – II SYSTEM IDENTIFICATION 9L

Non-Parametric methods: Transient analysis – Frequency analysis – correlation analysis – Spectral analysis – Parametric methods: Least square method – Recursive least square method – Neural network based identification.

UNIT – III DIGITAL CONTROLLER DESIGN 9L

Review of z-transform – Modified of z-transform – Pulse transfer function – Digital PID controller – Dead-beat controller, Dahlin's controller and Kalman's approach – Smith Predictor – Digital Feed-forward controller – Internal Model Controller.

UNIT – IV MULTI-LOOP REGULATORY CONTROL 9L

Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller – Biggest Log Modulus Tuning Method - Decoupling Control.

UNIT – V MULTI-VARIABLE REGULATORY CONTROL 9L

Introduction to Multivariable control – Multivariable PID Controller – Multivariable Internal Model Controller – Multivariable Dynamic Matrix Controller – Generalized Predictive Controller. Case Studies: - Computer control of a thermal process.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Analyze the solution for discrete time systems and test the stability of the systems(L4)
2. Relate the controllability, observability and stability of discrete time systems. (L1)
3. Build empirical models by parametric and non parametric methods(L3)
4. Design and analysis of various digital control techniques for SISO system. (L5)
5. Demonstrate the concept of RGA and decoupler for MIMO system. (L2)
6. Design a multiloop and multivariable control for industrial processes. (L6)

REFERENCES:

1. Gopal, M., “Digital Control and State Variable Methods”, Tata McGraw-Hill, 2003.
2. Deshpande P.B. & Ash R.H, "Computer Process Control", ISA publication, USA 1995.
3. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, “Process Dynamics and Control”, Wiley John and Sons, 3rd Edition, 2010.
4. Sigurd Skogestad, Ian Postlethwaite, “Multivariable Feedback Control: Analysis and Design”, John Wiley and Sons, 2005.

5. Stephanopoulos, G., “Chemical Process Control - An Introduction to Theory and Practice”, Prentice Hall of India, 2005.
6. Soderstorm, T. and Stoica, P., “System Identification”, Prentice Hall International Ltd., UK., 1989.
7. Bequette, B.W., “Process Control Modeling, Design and Simulation”, Prentice Hall of India, 2008.
8. P. Albertos and A. Sala, “Multivariable Control Systems an Engineering Approach”, Springer Verlag, 2006.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	2	2	-	-	-	1	3	2	-	-	-	-	-
CO 2	3	-	1	-	-	-	-	2	-	-	-	1	1	-	-
CO 3	3	2	-	-	-	-	-	-	3	2	-	3	2	-	-
CO 4	3	-	3	3	-	2	1	1	3	2	-	1	3	2	3
CO 5	3	-	-	-	-	-	-	-	2	2	-	2	-	-	3
CO 6	3	3	3	3	-	2	1	-	3	2	-	-	2	-	3
Avg.	3	2.3	2.25	2.6	-	2	1	1.3	3	2	-	1.75	2	2	3

1 - Low, 2-medium, 3-high, ‘-“- no correlation

EI23016 **ADVANCED PROCESS CONTROL**

L	T	P	C
3	0	0	3

UNIT – I DISCRETE STATE-VARIABLE TECHNIQUE 9L

State equation of discrete data system with sample and hold – State transition equation – Methods of computing the state transition matrix – Decomposition of discrete data transfer functions – State diagrams of discrete data systems – System with zero-order hold – Controllability and observability of linear time invariant discrete data system – Stability tests of discrete-data system.

UNIT – II NONLINEAR SYSTEMS 9L

Introduction – Nonlinear system elements – Linearization – Phase plane analysis – Lyapunov'smethod – Describing function method – Popov's method - Circle criterion.

UNIT – III OPTIMAL CONTROL SYSTEMS 9L

Parameter optimization:- Servo mechanisms - Regulators – Optimal control problems:- Transfer function approach - state variable approach – State regulator problem – Infinite-time regulator problem – output regulator and tracking problems - LQR and LQG.

UNIT – IV MULTIVARIABLE CONTROL 9L

Relative gain array and selection of control loops – Decoupler - Multivariable PID controller – Multi-loop PID controller – Model Based controller.

UNIT – V H-INFINITY CONTROLLER 9L

Introduction – Norms for Signals – Robust Stability – Robust Performance – Small Gain Theorem – Optimal H_2 Controller Design - H-Infinity Controller Design –– Effects of Weighting Functions in H-Infinity Control.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Formulate state equations and state transition equations for discrete data systems, analyze stability, controllability, and observability.
2. Perform nonlinear system analysis including linearization and stability.
3. solve parameter optimization problems for servo mechanisms and regulators, addressing optimal control problems
4. Analyze and design multivariable control systems using relative gain array for loop selection, implement decouplers, and design multivariable and multi-loop PID controllers, as well as model-based controllers.
5. Understand the concepts of signal norms, robust stability, and robust performance.
6. Integrate knowledge from discrete data systems, nonlinear systems, optimal control, multivariable control, and robust control methods to address complex control system design challenges in practical applications.

REFERENCES:

1. Gopal, M. "Modern Control System Theory", 2nd edition, Wiley Eastern Ltd, 1994.
2. Deshpande, P.B. and Ash, R.H., "Computer Process Control", ISA Publications, USA, 1995.
3. Nagrath, I.J. and Gopal, M., "Control Systems Engineering", 4th Edition, New-age International publishers, 2005.

4. Soderstorm, T. and Stoica, P., "System Identification", Prentice Hall International Ltd., UK., 1989.
5. Gopal, M., "Digital Control and State Variable Methods", Tata McGraw Hill, 2003.
6. Ogata, K., "Discrete-time Control Systems", 2nd Edition, Eastern Economy Edition, 2005.
7. Kuo, B.C., "Digital Control Systems", 2nd Edition, The Oxford University Press, 2005.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	1	-	-	-	1	-	1	-	3	-	1	1
CO2	3	1	3	1	2	-	-	1	-	1	-	3	-	1	1
CO3	3	3	3	2	3	-	-	1	-	1	-	3	-	-	1
CO4	3	3	3	3	3	2	2	1	2	2	1	3	1	1	3
CO5	3	3	3	3	3	2	2	1	2	2	1	3	1	1	3
CO6	3	3	3	3	3	2	2	1	2	2	1	3	1	3	3
Avg.	**3**	**2.7**	**2.8**	**2.2**	**2.8**	**2**	**2**	**1**	**2**	**1.5**	**1**	**3**	**1**	**1.4**	**2**

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23017 **MODEL BASED CONTROL**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION TO MIMO CONTROL 9L

Introduction to MIMO Systems-Multivariable control-Multiloop Control-Multivariable IMC-IMCPID-Case studies.

UNIT – II MODEL PREDICTIVE CONTROL SCHEMES 9L

Introduction to Model Predictive Control - Model Predictive Control Elements - Generalized Predictive Control Scheme – Multivariable Generalized Predictive Control Scheme – Multiple Model based Model Predictive Control Scheme Case Studies.

UNIT – III STATE SPACE BASED MODEL PREDICTIVE CONTROL SCHEME 9L

State Space Model Based Predictive Control Scheme - Review of Kalman Update based filters – State Observer Based Model Predictive Control Schemes – Case Studies.

UNIT – IV CONSTRAINED MODEL PREDICTIVE CONTROL SCHEME 9L

Constraints Handling: Amplitude Constraints and Rate Constraints –Constraints and Optimization – Constrained Model Predictive Control Scheme – Case Studies.

UNIT – V ADAPTIVE CONTROL SCHEME 9L

Introduction to Adaptive Control-Gain Scheduling-Self tuning regulators–MARS-Adaptive Model Predictive Control Scheme –Case Studies

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/ Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Explore various MIMO controllers presently used in industries.
2. Develop MPC, Adaptive and MIMO controllers for industrial processes.
3. Implement the controllers for MIMO systems.
4. Using software tools for practical exposures to the controllers used in industries by undergoing training.
5. Realisation of various optimization techniques for economical operation of process.

COURSE OUTCOMES:

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

1. Explain various control schemes on MIMO systems. (L1,L2)
2. Design controller for MIMO system. (L5)
3. Analyze the control schemes available in industries. (L4)
4. Design MPC, Adaptive controllers for practical engineering problems. (L5)
5. Choose suitable controllers for the given problems. (L3)

REFERENCES:

1. Coleman Brosilow, Babu Joseph, “Techniques of Model-Based Control”, Prentice Hall PTR Pub 2002.
2. E. F. Camacho, C. Bordons, “Model Predictive Control”, Springer-Verlag London Limited 2007.
3. K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Second Edition, Pearson Education Inc., second Edition 2008.

4. Paul Serban Agachi, Zoltan K. Nagy, Mircea Vasile Cristea, and Arpad Imre-Lucaci Model Based Control Case Studies in Process Engineering, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim 2006.
5. Ridong Zhang, Anke Xue FurongGao,“Model Predictive Control Approaches Based on the Extended State Space Model and Extended Non-minimal State Space Model”, Springer Nature Singapore Pte Ltd. 2019
6. J.A. ROSSITER “Model-Based Predictive Control A Practical Approach”, Taylor & Francis e-Library, 2005.

List of Open-Source Software/ Learning website:
1. https://nptel.ac.in/courses/103103037
2. https://nptel.ac.in/courses/108103007
3. https://onlinecourses.nptel.ac.in/noc21_ge01/preview
4. https://nptel.ac.in/courses/127106225

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	2	2	-	-	-	1	-	1	-	-	-	-	3
CO2	3	3	3	3	-	-	-	1	-	1	-	-	-	-	3
CO3	3	3	3	2	-	-	-	1	-	1	-	-	-	-	3
CO4	3	3	3	3	-	-	-	1	-	1	-	-	-	-	3
CO5	3	3	3	3	-	-	-	1	-	1	-	-	-	-	3
Avg.	3	2.8	2.8	2.6	-	-	-	1	-	1	-	-	-	-	3

1-low, 2-medium, 3-high, ‘-“- no correlation

EI23018 **NON LINEAR CONTROL**

L	T	P	C
3	0	0	3

UNIT – I STATE VARIABLE DESIGN 9L

Introduction to state Model- effect of state Feedback- Necessary and Sufficient Condition for Arbitrary Pole-placement- pole placement Design- design of state Observers- separation principle-servo design: -State Feedback with integral control.

UNIT – II PHASE PLANE ANALYSIS 9L

Features of linear and non-linear systems - Common physical non-linearities – Methods of linearization Concept of phase portraits – Singular points – Limit cycles – Construction of phase portraits – Phase plane analysis of linear and non-linear systems – Isocline method.

UNIT – III DESCRIBING FUNCTION ANALYSIS 9L

Basic concepts, derivation of describing functions for common non-linearities – Describing function analysis of non-linear systems – limit cycles – Stability of oscillations.

UNIT – IV OPTIMAL CONTROL 9L

Introduction - Time varying optimal control – LQR steady state optimal control – Solution of Ricatti's equation – Application examples.

UNIT – V OPTIMAL ESTIMATION 9L

Optimal estimation – Kalman Bucy Filter-Solution by duality principle-Discrete systems-Kalman Filter-Application examples.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/ Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Design of linear quadratic regulator (LQR) control system for any application of your own
2. Familiarization of Kalman filter in MATLAB
3. Seminar on pole placement design

COURSE OUTCOMES:

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

1. Apply the knowledge gained on state feedback control and nonlinear control. (L3)
2. Carryout analysis for common nonlinearities in a system. (L4)
3. Apply advanced control theory to practical engineering problems. (L3)
4. Design optimal controller. (L5)
5. Understand the basics and Importance of Kalman filter. (L1,L2)

REFERENCES:

1. G. J. Thaler, "Automatic Control Systems", Jaico Publishing House 1993.
2. M.Gopal, Modern Control System Theory, New Age International Publishers, 2002
3. K. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006.
4. G. J. Thaler, "Automatic Control Systems", Jaico Publishing House 1993.
5. M.Gopal, Modern Control System Theory, New Age International Publishers, 2002
6. K. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006.
7. Ashish Tewari, 'Modern Control Design with Matlab and Simulink', John Wiley, New Delhi, 2002.

8. K. Ogata, ‘Modern Control Engineering’, 4th Edition, PHI, New Delhi, 2002.
9. T. Glad and L. Ljung, “Control Theory –Multivariable and Non-Linear Methods”, Taylor & Francis, 2002.
10. D.S.Naidu, “Optimal Control Systems” First Indian Reprint, CRC Press, 2009.
11. William S Levine, “Control System Fundamentals,” The Control Handbook, CRC Press, Tayler and Francies Group, 2011.

List of Open-Source Software/ Learning website:

1. https://in.mathworks.com/discovery/kalman-filter.html
2. https://in.mathworks.com/help/control/getstart/design-an-lqr-servo-controller-insimulink.html
3. https://onlinecourses.nptel.ac.in/noc22_ee24/preview
4. http://www.nitttrc.edu.in/nptel/courses/video/101108047/lec22.pdf

MAPPING OF CO’S WITH PO’S AND PSO’S

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	2	2	-	-	-	3	-	3	-	1	-	-	3
CO2	3	3	3	2	-	-	-	3	-	3	-	1	-	-	3
CO3	3	2	2	2	-	-	-	3	-	3	-	1	-	-	3
CO4	3	3	3	3	-	-	-	3	-	3	-	1	-	-	3
CO5	2	1	2	1	-	-	-	2	-	2	-	1	-	-	3
Avg.	2.8	2.2	2.4	2	-	-	-	2.8		2.8	-	1	-	-	3

1. low, 2-medium, 3-high, ‘-“- no correlation

EI23019 **FAULT TOLERANT CONTROL**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION & ANALYTICAL REDUNDANCY CONCEPTS 9L

Introduction - Types of faults and different tasks of Fault Diagnosis and Implementation - Different approaches to FDD: Model free and Model based approaches - Introduction- Mathematical representation of Faults and Disturbances: Additive and Multiplicative types – Residual Generation: Detection, Isolation, Computational and stability properties – Design of Residual generator – Residual specification and Implementation

UNIT – II DESIGN OF STRUCTURED RESIDUALS & DIRECTIONAL STRUCTURED RESIDUALS 9L

Introduction- Residual structure of single fault Isolation: Structural and Canonical structures - Residual structure of multiple fault Isolation: Diagonal and Full Row canonical concepts – Introduction to parity equation implementation and alternative representation – Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation

UNIT – III FAULT DIAGNOSIS USING STATE ESTIMATORS 9L

Introduction – State Observer – State Estimators – Norms based residual evaluation and threshold computation - Statistical methods based residual evaluation and threshold settings: Generalized Likelihood Ratio Approach – Marginalized Likelihood Ratio Approach.

UNIT – IV FAULT TOLERANT CONTROL 9L

Introduction – Passive Fault-tolerant Control- Active Fault tolerant Control - Actuator and Sensor Fault tolerance Principles:- Compensation for actuator – Sensor Fault-tolerant Control Design – Fault-tolerant Control Architecture - Fault-tolerant Control design against major actuator failures.

UNIT – V CASE STUDIES 9L

Fault tolerant Control of Three-tank System – Diagnosis and Fault-tolerant control of chemical process – supervision of steam generator – Different types of faults in Control valves – Automatic detection, quantification and compensation of valve stiction

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Ability to:

1. Compare different approaches to Fault Detection and Diagnosis
2. Design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach
3. Design and detect faults in sensor and actuators using GLR and MLR based Approaches
4. Compare various types of fault tolerant control schemes such as Passive and active approaches
5. Design fault-tolerant control scheme in the presence of actuator failures
   Detect and quantify and compensate stiction in Control valves

REFERENCES:

1. Janos J. Gertler, “Fault Detection and Diagnosis in Engineering systems”,2nd Edition, Marcel Dekker, 1998.

2. Rolf Isermann, Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance, Springer Verlag, 2006.
3. Steven X. Ding, Model based Fault Diagnosis Techniques: Schemes, Algorithms, and
4. Hassan Noura, Didier Theilliol, Jean-Christophe Ponsart, Abbas Chamseddine, Fault-Tolerant Control Systems: Design and Practical Applications, Springer Publication, 2009.
5. Mogens Blanke, Diagnosis and Fault-Tolerant Control, Springer, 2006.
6. Ali Ahammad Shoukat Choudhury, Sirish L. Shah, Nina F. Thornhill, Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches, Springer, 2008.Tools, Springer Publication, 2012.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	-	-	-	-	-	-	1	3	2	-	2	-	3	3
CO2	3	-	3	-	3	-	-	1	3	2	-	2	3	3	3
CO3	3	-	3	-	3	-	-	1	3	2	-	1	-	3	3
CO4	3	-	3	-	3	-	-	1	3	2	-	1	3	3	3
CO5	3	3	3	3	3	-	-	1	3	2	-	1	3	3	3
CO6	3	-	-	3	-	-	-	1	-	-	-	-	-	-	3
Avg.	3	3	3	3	3	-	-	1	3	2	-	1.4	3	3	3

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23020 **ADAPTIVE CONTROL**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION 9L

Introduction - Adaptive Schemes - The adaptive Control Problem – Applications - Real-time parameter estimation: - Least squares and regression methods- Estimating parameters in dynamical systems

UNIT – II GAIN SCHEDULING 9L

Introduction- The principle - Design of gain scheduling controllers- Nonlinear transformations - application of gain scheduling - Auto-tuning techniques: Methods based on Relay feedback

UNIT – III DETERMINISTIC SELF-TUNING REGULATORS 9L

Introduction- Pole Placement design - Indirect Self-tuning regulators - direct self-tuning regulators – Disturbances with known characteristics

UNIT – IV STOCHASTIC AND PREDICTIVE SELF-TUNING REGULATORS 9L

Introduction – Design of minimum variance controller - Design of moving average controller - stochastic self-tuning regulators

UNIT – V MODEL – REFERENCE ADAPTIVE SYSTEM ATIONS 9L

Introduction- MIT rule – Determination of adaptation gain - Lyapunov theory –Design of MRAS using Lyapunov theory – Relations between MRAS and STR.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Understand the basic concepts and problems associated with adaptive control systems, including real-time parameter estimation techniques.
2. Apply gain scheduling principles and design techniques to create adaptive controllers.
3. Design and implement deterministic self-tuning regulators, including both indirect and direct approaches.
4. Develop stochastic self-tuning regulators and predictive controllers, including the design of minimum variance and moving average controllers.
5. Design model-reference adaptive systems (MRAS) using the MIT rule and Lyapunov theory.

REFERENCES:

1. K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Second Edition, Pearson Education Inc., 1995
2. T. Soderstorm and Petre Stoica, “System Identification”, Prentice Hall International(UK) Ltd., 1989.
3. N.Mathivanan, ”PC-based Instrumentation Concepts and Practice”, Eastern Economy Edition, PHI Learning private ltd ,2009
4. Lennart Ljung, “System Identification: Theory for the User”, Second Edition, Prentice Hall, 1999

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	-	2	2	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	2	1	-	-	-	-	2	-	-	-	-	-	-
CO3	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-
CO4	1	-	1	-	-	-	-	-	2	-	-	-	-	-	-
CO5	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-
Avg.	1	-	1.4	1.5	-	-	-	-	2	-	-	-	-	2	-

1 - low, 2-medium, 3-high, '-"- no correlation

VERTICAL IV - APPLIED INSTRUMENTATION

EI23021	INSTRUMENTATION STANDARDS	L	T	P	C
		3	0	0	3

UNIT – I STANDARDS ORGANIZATION 9L

Standards: Introduction International and National Standards organization: IEC, ISO, NIST, IEEE, ISA, API, BIS, DIN, JISC and ANSI.

API: Process Measurement and Instrumentation (APIRP551): recommended practice for installation of the instruments – flow, level, temperature, pressure - Process Instrument and Control (API RP554): performance requirements and considerations for the selection, specification, installation and testing of process instrumentation and control systems.

UNIT – II ISA STANDARDS 9L

Documentation of Measurement and Control, Instruments and System (ISA 5): 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7 - General Requirements for Electrical Equipment in Hazardous Location (ISA 12): 12.2, 12.4, 12.24, 12.29 – Instrument Specification Forms (ISA20): – Measurement Transducers (ISA37)

UNIT – III ISA STANDARDS - CONTROL VALVE AND ACTUATOR 9L

Control Valve Standards (ISA75): 75.01, 75.04, 75.05, 75.7, 75.11, 75.13, 75.14, 75.23, 75.24, 75.26. Valve Actuator (ISA 96): 96.01, 96.02, 96.03, 96.04.

UNIT – IV ISA STANDARDS - FOSSIL AND NUCLEAR POWER PLANTS 9L

Fossil Power Plant Standards (ISA 77): 77.14, 77.22, 77.30, 77.41, 77.42, 77.44, 77.60, 77.70. Nuclear Power Plant Standards (ISA67): 67.01, 67.02, 67.03, 67.04, 67.06.

UNIT – V BS , ISO, IEC, & ANSI 9L

Measurement of Fluid Flow by means of Orifice Plates (ISO 5167/ BSI042) IEC 61131-3 – Programmable Controller – Programming Languages – Specification for Industrial Platinum Resistance Thermometer Sensors (BSI904) – International Thermocouple Reference Tables (BS4937) – Temperature Measurement Thermocouple (ANSIC96.1).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Understand the role of standards organization
2. Ability to implement different standards related to installation and control system, programming, documentation, equipments in hazardous area and instrument specification forms.
3. Skill to utilize standards related to control valve, actuators. orifice sizing, RTD and thermocouple
4. Capability to implement standards related to power plant and nuclear power plant.
5. Ability to select different standards related to orifice ,RTD and thermocouple.
6. Select standards related to programming language.

REFERENCES:

1. API Recommended Practice 551, "Process Measurement Instrumentation", American Petroleum Institute, Washington, D.C., Second Edition, May 2001.
2. API Recommended Practice 554, "Process Instrumentation and Control – 3 parts", American Petroleum Institute, Washington, D.C., First Edition, October 2008.
3. ISA standard 5, "Documentation of Measurement and Control Instruments and Systems", ISA, North Carolina, USA.
4. ISA standard 12, "Electrical Equipment for Hazardous Locations", ISA, North Carolina, USA.
5. ISA standard 20, "Instrument Specification Forms", ISA, North Carolina, USA.
6. ISA standard 37, "Measurement Transducers", ISA, North Carolina, USA.
7. ISA standard 75, "Control Valve Standards", ISA, North Carolina, USA.
8. ISA standard 96, "Valve Actuator", ISA, North Carolina, USA.
9. ISA standard 77, "Fossil Power Plant Standards", ISA, North Carolina, USA.
10. ISA standard 67, "Nuclear Power Plant Standards", ISA, North Carolina, USA.
11. BS EN 60584-1, "Thermocouples - EMF specifications and tolerances", British Standard, 2013.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	-	-	-		2	1	-	-	-	-	-	-	-	-	-
CO 2	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1
CO 4	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	1	-	1	-	-	-	-	-	-	-	-	1
Avg.	-	-	-	1	2	1	-	-	-	-	-	-	1	-	1

1 - Low, 2-medium, 3-high, '-"- no correlation

EI23022 **FIBER OPTICS AND LASER INSTRUMENTATION**

L	T	P	C
3	0	0	3

UNIT – I OPTICAL FIBER AND THEIR PROPERTIES **9L**

Principles of light propagation through a fiber – laws related to light propagation through fiber – Different types of fibers and their properties, Fiber manufacturing – mechanical and transmission characteristics – Connectors & splicers – Fiber termination – Optical sources – Optical detectors.

UNIT – II FIBER OPTIC SENSORS 9L

Fiber optic sensors – Fiber optic instrumentation system for measurement of fiber characteristics – Different types of modulators – Interferometric method for measurement of length – Measurement of pressure, temperature, electric field, liquid level and strain

UNIT – III LASER FUNDAMENTALS 9L

Fundamental characteristics of lasers – Three level and four level lasers – Properties of lasers – Laser modes – Resonator configuration – Q-switching and mode locking – Types of lasers:– Gas lasers, solid lasers, liquid lasers, semiconductor lasers, Excimer lasers & Vertical-Cavity Surface Emitting laser (VCSEL).

UNIT – IV INDUSTRIAL APPLICATION OF LASERS 9L

Applications of Low Power Lasers: - Measurement of distance, length, velocity and acceleration using lasers, & Environmental monitoring using lasers. Applications of High Power Lasers: Material processing – Laser heating, welding, melting and trimming of material, Material Removal & vaporization.

UNIT – V HOLOGRAPHY AND MEDICAL APPLICATIONS OF LASERS 9L

Holography – Principles – Methods. – Holographic interferometry and applications, Holography for nondestructive testing – Medical applications of lasers – laser and tissue interaction – Laser instruments for surgery – Safety methods for medical lasers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain the principles of light transmission, characteristics and losses in optical fibers for measurement applications. (L1)
2. Apply the concepts of optical fibers and lasers for its use in sensor development as well as applications in production, manufacturing and industrial applications. (L3)
3. Compare the lasing theory of various laser generation systems. (L2, L4)
4. Describe the laser systems for measurement of physical quantities and for industrial applications. (L2)
5. Select lasers for a specific Industrial and medical application. (L2)
6. Apply/Build mathematical methods/models for lasing theory and fiber optics. (L5, L6)

REFERENCES:

1. Mitschke, F. (2016). Fiber optics: physics and technology. (Second Edition). Springer.
2. Eric Udd, William B., and Spillman, Jr., “Fiber Optic Sensors: An Introduction for Engineers and Scientists “, John Wiley & Sons, 2011.
3. Monte Ross, “Laser Applications”, McGraw-Hill, 1968.

4. John F. Ready, “Industrial Applications of Lasers”, Academic Press, Digitized in 2008.
5. Hariharan, P. (2002). Basics of holography. Cambridge university press.
6. Keiser, G., “Optical Fiber Communication”, McGraw-Hill, 3rd Edition, 2000.
7. Daly, J. C. (2018). Fiber Optics: Second Edition. CRC Press.
8. John and Harry, “Industrial lasers and their application”, McGraw-Hill, 2002.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	3	-	-	-	-	-	1	-	1	-	-	2	-	-
CO 2	-	3	3	-	-	-	-	2	-	1	-	3	2	-	-
CO 3	-	-	-	-	3	-	-	1	-	1	-	-	2	-	-
CO 4	-	-	3	-	2	-	-	2	-	1	-	2	2	-	-
CO5	-	-	-	-	2	3	-	2	-	1	-	-	2	-	-
CO 6	-	-	-	-	2	-	-	2	-	1	-	3	2	-	-
Avg.	3	3	3	-	2.25	3	-	1.7	-	1	-	2.7	2	-	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23023 **NANO SCIENCE AND INSTRUMENTATION**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY **9L**

Nano scale Science and Technology – Classifications of nano structured materials – nano particles – quantum dots, Nano wires – ultrathin films – multilayered materials. Length Scales involved and effect on material properties – Nano toxicology – Nano Safety – Clean rooms.

UNIT – II SYNTHESIS TECHNIQUES 9L

Top-down Approaches: – Mechanical Milling – planetary ball mill – ball materials – vibratory mill. Bottom-up approaches: - Physical Vapour Deposition (PVD): – Inert Gas Condensation (IGC), Laser Ablation & Wire Explosion. - Chemical Vapour Deposition (CVD):- Thermally activated CVD & Plasma Enhanced CVD – Epitaxy: - Metal Organic Chemical Vapor Deposition (MOCVD), Molecular Beam Epitaxy (MBE) & Atomic Layer Deposition (ALD).

UNIT – III NANO SENSORS AND DEVICES: FABRICATION AND CONCEPTS 9L

Patterning: - Direct and Indirect writing - Photolithography – UV lithography - electron beam lithography - X-ray Lithography - Ion Beam Lithography, Atomic Force Microscope based Lithography – Scanning Tunneling Microscope based Lithography - Dip pen lithography. Nano sensing:- Nanowire sensors, - Nanotube sensors, - Nanocantilever sensors, - Nano-biosensors

UNIT – IV NANOSAFETY AND CLEAN ROOM PRINCIPLES **9L**

Nanotoxicology – Nano safety – Environmental effects - Clean rooms specifications – Clean Room Contaminants – Clean room principles:- Laminar flow and turbulent flow clean rooms – Clean Room Construction and Design:- Bay Chase Clean Room, Ball Room Clean Room & Micro Environment Clean Room.

UNIT – V INSTRUMENTS FOR CHARACTERIZATION OF NANOMATERIALS **9L**

X- Ray Diffraction technique - Scanning Electron Microscopy – Transmission Electron Microscopy – Atomic Force Microscope - Scanning Tunneling Microscope - Nano indentation system.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain the principles of nano science along with the properties of nano materials for the design of novel systems. (L1)
2. Describe and compare the various techniques for synthesis of nano materials for specified applications. (L2, L3)
3. Compare and analyze the various patterning techniques for development of micro and nano scale devices. (L3, L4))
4. Analyze/examine the toxic effects of nano materials along with the safety measures for nano technological research. (L3, L4)

5. Analyze, compare and select the instrumentation systems for characterization of nano materials. (L5)
6. Compare the various transduction methods for nano sensors. (L2)

REFERENCES:

1. Mickwilson et al, “Nano Technology: Basic science and Emerging Technologies”, Chapman & Hall/CRC Press, 2004.
2. Jeremy J.Ramsden, “Nano Technology: An Introduction”, Elsevier Publication, 2011.
3. Murty, B. S., Shankar, P., Raj, B., Rath, B. B., &Murday, J., “Textbook of nanoscience and nanotechnology”, Springer Science & Business Media, 2013.
   Edelstein, A.S., and Cammearata, R.C., eds., “Nano materials: Synthesis, Properties and Applications”, Institute of Physics Publishing, Bristol and Philadelphia, 1996.
4. Timp, G., (Editor), “Nanotechnology”, AIP press/Springer, 1999.
5. Bhushan, B. (Ed.), “Springer handbook of nanotechnology”, Springer Science & Business Media, 2010.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	-	-	-	-	-	1	-	1	-	-	-	-	-
CO 2	-	-	-	-	3	-	-	1	3	1	-	3	-	-	-
CO3	-	-	3		3	-	-	1	3	1	-	3	-	2	-
CO4	-	-	-	-		-	3	1	-	1	-	-	-	-	-
CO5	-	-	-	-	3	-	-	1	3	1	-	3	-	-	-
CO6	-	2	-	-	-	-	-	1	-	1	-	3	3	-	-
Avg.	3	2.5	3	-	3	-	3	1	3	1	-	3	3	2	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23024 **ANALYTICAL INSTRUMENTATION**

L	T	P	C
3	0	0	3

UNIT – I FUNDAMENTALS OF ANALYTICAL INSTRUMENTATION **9L**

Types of chemical analysis-Elements of analytical Instrument-Methods of analysis-Performance requirements of Analytical Instruments-Instrument Calibration Techniques.

UNIT – II SPECTROPHOTOMETERS 9L

Interaction of radiation with matter – Beer-Lambert law – UV Visible spectrophotometer –FTIR Spectrophotometer - Atomic absorption spectrophotometer - Atomic emission spectrophotometer– Flame Emission spectrophotometer- Mass Spectrometer - NMR Spectrometer - Construction, working, Advantages, Limitations and Applications.

UNIT – III WATER POLLUTION AND ENVIRONMENTAL POLLUTION ANALYSERS 9L

Ph Sensor – Conductivity Sensor – Turbidity - Dissolved Oxygen Analyser –CO, So_x and NO_x Analysers – Hydrocarbon Analyser – Particulate matter analyser – Ozone Analyser- Construction, working, Advantages, Limitations and Applications.

UNIT – IV CHROMATOGRAPHY 9L

General principles – classification – chromatographic behavior of solutes – quantitative determination – Gas chromatography - High-pressure liquid chromatography – Gas Chromatograph with Mass Spectrometer- Liquid Chromatograph with Mass Spectrometer- Construction, working, Advantages, Limitations and Applications.

UNIT – V ANALYSERS 9L

Thermo gravimetric Analyser - differential thermal analyser– Radiation detectors: Ionisation detector, GM counters, Proportional Counter – Differential Scanning Calorimetry – Dust and Smoke Analyser - Construction, working, Advantages, Limitations and Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Remember the basic elements and working principle of different methods of chemical analysis. (L1)
2. Understand the operation of different spectroscopic techniques, chromatography and other common chemical analyzers. (L2)
3. Select/ demonstrate an analytical instrument, interpret the analyzer results and solve numerical problems using relevant software. (L3)
4. Analyse a problem/ compare between different analytical instruments. (L4)
5. Develop an analysis method or provide solutions to a problem statement. (L6)
6. Evaluate an analysis method for the given sample or evaluate performance characteristics of a given chemical analyzer. (L5)

REFERENCES:

1. Braun, R.D., “Introduction to Instrumental Analysis”, Pharma Book Syndicate, Singapore, 2nd edition 2012.

2. Khandpur, R.S., “Handbook of Analytical Instruments”, Tata McGraw Hill publishing Co. Ltd., 5th edition 2018.
3. Liptak, B.G., “Process Measurement and Analysis”, CRC Press, 5th edition, 2016.
4. Ewing, G.W., “Instrumental Methods of Chemical Analysis”, McGraw Hill, 5th edition reprint 1985. Digitized in 2007.
5. Willard, H.H., Merritt, L.L., Dean, J.A., Settle, F.A.,” Instrumental methods of analysis”, CBS publishing & distribution, 7th Edition, 2012**.**

MAPPING OF COs WITH POs AND PSOs

CO’S	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO3	-	3	3	2	3	-	2	-	-	-	-	-	3	-	-
CO4	-	2	3	3	-	2	2	-	2	-	2	2	3	-	-
CO5	-	2	3	3	-	2	2	-	2	2	2	2	3	-	-
CO6	-	3	3	3	-	2	2	2	2	2	2	2	3	-	-
Avg.	3	2.3	3	2.8	3	2	2	2	2	2	2	2	3	-	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23025	CONTROL VALVES	L	T	P	C
		3	0	0	3

UNIT – I INTRODUCTION TO CONTROL VALVES 9L

Basics Of Control Valves, Importance of Control Valve in Process Industry, Basic Terminologies, Sliding Stem Control Valve, Rotatory Stem Control Valve Terminologies, Types of Control Valves-Globe Valve, Sanitary Valves, Rotary Valves. Valve Trim Types.

UNIT – II ACTUATORS AND CONTROL VALVE ACCESSORIES 9L

Actuators – Schematics, Working of Actuator, Types of Actuators- Hydraulic, Pneumatic, Electrical Actuators. Pneumatic Actuator: Linear- Spring &Diaphragm, Piston Type, and Rotary: Scotch Yoke, Rack and Pinion. Valve Body Bonnets, Control Valve Packing, Control Valve Accessories-Positioner and its Types, I/P Coil, Volume Boosters, Position Transmitters, Limit Switches, Solenoid Valves. Special Control Valves.

UNIT – III VALVE CHARACTERISTICS, SIZING AND SELECTION 9L

Valve Performance and Characteristics for Different Types of Valves, Dead Band – Causes, Effects, Performance Test, Valve Response Time- Importance of Supply Pressure, Dead Time and Solutions to Minimize Dead Time. Valve Sizing, Actuator Sizing, Valve Selection, Actuator Selection.

UNIT – IV COMMON CONTROL VALVE PROBLEMS 9L

Cavitation and Flashing – valve stiction -, Control Valve Noise- Noise Prediction and Reduction Techniques, General Valve Problems Valve Passing, Valve Stuck Up, Calibration Issues, Packing Leak, Insufficient Flow. Control Valve Installation and Commissioning Guidelines, Environmental and Application Consideration for valve selection..

UNIT – V QUALITY TESTS AND STANDARDS 9L

Quality Check of Control Valves, Non-Destructive Testing: Radiography Test, Ultrasonic Test, Leak and Liquid Penetrating Test, Magnetic Particle Testing. Factory Acceptance Test, Control Valve and Actuator Maintenance, Control Valve Diagnostics, ISA 75.25.01: 2000: Test Procedure for Control Valves Response Measurement from Step Inputs,IEC60534-4 : 2006: Industrial Process Control Valves - Inspection &Routine Testing

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Understand terminologies associated with control valves. (L1)
2. Determine the characteristic features of different types of control valves. (L2)
3. Compare the merits and limitations of different types of actuators. (L2)
4. Analyse and recommend appropriate control valves characteristics for a given application. (L4)
5. carry out design calculations for control valves. (L5)
6. Evaluate the common problems associated with control valves outline. (L3)
7. Comment on different quality testing methods for control valves. (L2)
8. Interpret the industry popular standards for control valves diagnostics and testing procedure.(L2)

REFERENCES:

1. Control system components, M.D.Desai, PHI Learning.
2. ISA Handbook for control valves, James W Hutchison, ISA.
3. Instrumentation Engineer's Handbook, B.G.Liptak, Chilton Book co., Philadelphia.
4. Valve selection Handbook- R.W.Zappe Gulf Publishing Co., Huston.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	-	-	-	-	-	-	1	-	1	-	-	-	-	-
CO2	3	-	-	-	-	-	-	1	-	1	-	-	-	-	-
CO3	3	-	-	-	-	-	-	1	-	1	-	-	-	-	-
CO4	3	3	-	3		-	-	1	-	1	-	-	-	3	-
CO5	3		3	3	3	-	-	1	-	1	-	-	-	3	-
CO6	3	3	-	3	-	-	-	1	-	1	-	3	-	-	-
CO7	3	-	-	-	-	-	-	1	-	1	-	-	-	3	-
CO8	3	-	-	3	3	-	-	1	-	1	-	3	-	3	-
Avg.	3	3	3	3	3	-	-	1	-	1	-	3	-	3	-

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23026 THERMAL POWER PLANT INSTRUMENTATION

	L	T	P	C
	3	**0**	**0**	**3**

UNIT – I OVERVIEW OF POWER GENERATION 9L

Survey of methods of power generation – hydro, thermal, nuclear, solar and wind power – Importance of instrumentation in power generation – Thermal power plant – Building blocks – Combined Cycle System – Combined Heat and Power System – sub critical and supercritical boilers.

UNIT – II MEASUREMENTS IN POWER PLANTS 9L

Measurement of feed water flow, air flow, steam flow and coal flow – Drum level measurement– Steam pressure and temperature measurement – Turbine speed and vibration measurement – Flue gas analyzer – Fuel composition analyzer.

UNIT – III BOILER CONTROL – I 9L

Combustion of fuel and excess air – Firing rate demand – Steam temperature control – Control of deaerator – Drum level control: Single, two and three element control – Furnace draft control – implosion and explosion – flue gas dew point control – Trimming of combustion air – Soot blowing.

UNIT – IV BOILER CONTROL – II 9L

Burners for liquid and solid fuels – Burner management – Furnace safety interlocks – Coal pulverizer control – Combustion control for liquid and solid fuel fired boilers – air/fuel ratio control– fluidized bed boiler – Cyclone furnace.

UNIT – V TURBINE MONITORING AND CONTROL 9L

Types of steam turbines – Turbine governing system– Speed and Load control – Transient speed rise – Free governor mode operation – Automatic Load Frequency Control – Turbine oil system – Oil pressure drop relay – Oil cooling system– Turbine run up system. Case studies on failure modes: Fouling of Boiler tubes, plant problems and troubleshooting - Root cause analysis.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/ Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. A seminar on Role of control and instrumentation in thermal power plant.
2. Design and verification of any simple power plant circuit through simulation.
3. Introduction to other power plants in the world not covered in the above syllabus.
4. Quiz on power plants, boiler control and turbine monitoring.

COURSE OUTCOMES:

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

1. Understand and analyze the process diagram of hydel, thermal, nuclear, wind andsolar power plants. (L2)
2. Identify the instruments for monitoring various parameters related to thermal power plant. (L1)
3. Analyze and select appropriate control strategy for various systems involved in thermal power plant. (L4)
4. Recognize the important terms related to turbine monitoring system and able to analyze the problems related to turbine governing.(L1)
5. Understand the concepts of safety interlocks applied for combustion process.(L1)

REFERENCES:

1. Sam Dukelow, "Control of Boilers", Instrument Society of America, 1991.
2. Gill, A.B., "Power Plant performance",Elsevier 2016.
3. Krishnaswamy, K. and Ponnibala, M., "Power Plant Instrumentation", PHI Learning Pvt. Ltd., New Delhi, Fourth Printing (Second Edition) August, 2013.
4. Liptak B.G., "Instrumentation in Process Industries", Chilton Book Company, 2005. Digitized in 2008
5. Jain R.K., "Mechanical and Industrial Measurements", Khanna Publishers, New Delhi, 3rd edition **2017.**

List of Open-Source Software/ Learning website:

1. https://nptel.ac.in/courses/112107291
2. https://instrumentationtools.com/drum-level-control-systems/
3. https://nptel.ac.in/courses/112103243
4. https://jntua.ac.in/gate-online-classes/registration/downloads/material/a159185656721.pdf
5. https://kanchiuniv.ac.in/coursematerials/LECTURENOTESEIEPHASE2/POWER%20PLANT %20INSTRUMENTATION%20-%20TS.pdf
6. https://www.ni.com/en-in/innovations/white-papers/08/wind-turbine-control-methods.html

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	3	1	-	2	2	1	-	1	-	-	2	-	2
CO2	3	-	3	1	-	2	-	1	-	1	-	-	2	-	2
CO3	3	-	3	1	1	2	2	1	-	1	-	-	2	-	2
CO4	3	-	3	1	-	2	2	1	-	1	-	-	2	-	2
CO5	3	-	3	1	1	2	2	1	-	1	-	-	2	-	2
Avg	3	1	3	1	2	2	2	1	-	1	-	-	2	-	2

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23027 **INSTRUMENTATION IN OIL AND GAS INDUSTRY**

L	T	P	C
3	0	0	3

UNIT – I OIL EXTRACTION AND OIL GAS PRODUCTION 9L

Techniques used for oil discovery – Oil recovery methods – oil rig system - Overview of oil gas production – oil gas separation – Gas treatment and compression – Control and safety systems.

UNIT – II MAJOR UNIT OPERATIONS IN REFINERY 9L

Distillation Column – Thermal cracking – Catalytic Cracking – Catalytic reforming – mathematical Modelling and selection of appropriate control strategy – Alkylation – Isomerization.

UNIT – III DERIVATIVES FROM PETROLEUM 9L

Derivatives from methane – Methanol Production – Acetylene production - Derivatives from acetylene —Derivatives from ethylene – Derivatives from propylene.

UNIT – IV IMPORTANT PETROLEUM PRODUCTS & MEASUREMENTS 9L

BTX from Reformate – Styrene – Ethylene oxide/Ethylene glycol – polyethylene – Polypropylene – PVC production. Parameters to be measured in refinery and petrochemical industry – Selection and maintenance of measuring instruments.

UNIT – V SAFETY SYSTEMS 9L

Hazardous zone classification – Electrical and Intrinsic safety – Explosion suppression and Deluge systems – Flame, fire and smoke detectors – leak detectors – Guidelines and standards – General SIS Design Configurations – Hazard and Risk Assessment – Failure modes – Operation and Maintenance.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/ Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. A Seminar on Role of Instrumentation in petrochemical industry.
2. Selection of petroleum products for applications.
3. Familiarization of any one relevant software tool (MATLAB/ SCILAB/ LABVIEW/ Proteus/ Equivalent open-source software)
4. Quiz on derivatives, refinery and other petroleum products.
   Introduction to other advanced detectors not covered in the above syllabus

COURSE OUTCOMES:

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

1. Sketch the oil gas production process and important unit operations in a refinery. (L3)
2. Infer the process knowledge, ability to develop and analyze mathematical model of selective processes. (L2)
3. Analyze and select appropriate control strategy for selective unit operations in a refinery. (L4)
4. Identify the most important chemical derivatives obtained from petroleum
5. products.(L1)
   Understand safety instrumentation followed in process industries. (L2)

REFERENCES:

1. Waddams, A.L., “Chemicals from Petroleum”, Wiley, 1978. (Digitized in 2007).
2. Balchen, J.G., and Mumme K.I., “Process Control Structures and Applications”, Von Nostrand Reinhold Company, New York, 1988.
3. Liptak, B.G., “Instrumentation in Process Industries”, Chilton Book Company, 2005. (Digitized in 2008).
4. Austin, G.T. and Shreeves, A.G.T., “Chemical Process industries”, McGraw-Hill, 5th edition 2017.
5. Havard Devold, “Oil and Gas Production Handbook”, ABB, edtion 3.0, 2013.
6. Paul Gruhn and Harry Cheddie, “Safety Instrumented Systems: Design, Analysis, and Justification”, 2nd Edition, ISA Press, 2006. (Digitized in 2009).

List of Open-Source Software/ Learning website:

1. https://whatispiping.com/safety-instrumented-systems-sis/
2. https://www.britannica.com/technology/petroleum-refining/Petroleum-products-and-their-uses
3. https://uma.ac.ir/files/site1/m_ghorbanpour_6ffe535/refinery_3.pdf
4. https://www.omicsonline.org/conferences-list/petroleum-derivatives-synthesis-and-application
5. https://folk.ntnu.no/onshus/Oil%20and%20gas%20production%20handbook%20ed1x3a5%20comp.pdf
6. https://nptel.ac.in/courses/114106039
7. https://library.e.abb.com/public/34d5b70e18f7d6c8c1257be500438ac3/Oil%20and%20gas%20production%20handbook%20ed3x0_web.pdf

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	2	2	-	-	-	1	-	1	-	-	3	-	-
CO2	2	2	2	2	-	-	-	1	-	1	-	-	3	-	-
CO3	3	3	3	2	-	-	-	1	-	1	-	-	3	-	3
CO4	1	1	1	1	-	-	-	1	-	1	-	-	3	-	-
CO5	2	2	2	2	-	-	-	1	-	1	-	-	3	-	3
Avg.	2.2	2	2	1.8	-	-	-	1	-	1	-	-	3	-	3

1-low, 2-medium, 3-high, ‘-“- no correlation

EI23028 **INSTRUMENTATION FOR NUCLEAR POWER PLANT**

L	T	P	C
3	0	0	3

UNIT – I FUNDAMENTAL CONSIDERATIONS IN NUCLEAR POWER REACTOR **9L**

Nuclear and Fossil Fuels, Definitions: Nuclear Terms, Fission Process Terms, Nuclear Reactor Terms, Nuclear Reactor Kinetics: Point Kinetics without delayed neutrons – Point Kinetics with delayed neutrons, Reactivity, Inhour equation, Effects of reactivity Insertions, Reactivity changes –Three Dimensional Kinetics.

UNIT – II MEASURING INSTRUMENTS AND ANALYZER IN NUCLEAR POWERPLANT 9L

Nuclear Radiation Sensors – Out-of-Core – Neutron Sensors – In-Core – Process I and Position Sensing, Steam Properties Sensing, Water Properties Sensing, Gas Properties Sensing – Special sensor for Sodium cooled reactors and gas cooled reactors.

UNIT – III TYPES OF NUCLEAR POWER REACTOR 9L

Pressurized Water Reactor – Boiling Water Reactor – Pressurized Heavy Water Reactor – Sodium Cooled Fast Reactor – Advanced Gas Cooled Reactor instrumentation: Temperature Sensing, Pressure Sensing and transmitting, Flow Sensing, Level.

UNIT – IV NUCLEAR WASTE DISPOSAL AND REACTOR SAFETY 9L

Types of Radioactive Wastes : Exempt waste and very low level waste, Low level waste, Intermediate Level waste, High level waste – Treatment and conditioning of Nuclear waste - Waste Disposal Methods, Nuclear Reactor Safety: Introduction, Accident Prevention, Engineered safety features, Abnormal Event Analysis – Licensing design basis Evaluation.

UNIT – V MODELING AND CONTROL OF NUCLEAR POWER REACTOR 9L

Multipoint Kinetics modeling of Large reactors: Introduction, Derivation of Multipoint Kinetics model, Selection of suitable nodalization scheme, Application to the AHWR Thermal hydraulics model, Coupled Neutronics –Thermal Hydraulics model – Reactor Stability Analysis – Control of Nuclear Power: General features of Reactor control, Methods of control, control loops , Effectiveness of control rods, Output Feedback control design - Direct block diagonalization and composite control of Three time scale systems – Design of Fast output sampling controller for Three time scale systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Be able to recognize and recall the basics of nuclear reactor terminology, definitions, and concepts associated with nuclear reactor physics.
2. Be able to understand and select appropriate instrument from the types of radiation measurement equipment and nuclear power plant instrumentation.
3. Be able to identify and summarize the specific features of different types of nuclear reactors.
4. Be able to understand the role and responsibility of effective nuclear waste disposal.
5. Be able to apply their mathematical knowledge and engineering principles to model the nuclear reactor and able to control the reactor.

6. Be able to carry out necessary simulation of models of different types of Nuclear reactors and design appropriate controllers using modern IT tools

REFERENCES:

1. Shimjith, S.R., Tawari A.P., and Bandyopathy, B. “Modeling and Control of a Large Nuclear reactor”, BARC Mumbai, India.
2. Yoshiaki Oka and Katsuo Suzuki, “Nuclear Reactor Kinetics and Plant Control”, An Advanced Course in Nuclear Engineering, Springer Japan.
3. James J. Duderstadt and Louis J. Hamilton, “Nuclear Reactor Analysis” Wiley, 1st Edition,1976.
4. NPTEL Video Lectures on “Nuclear Reactors and Safety - An Introduction” by Dr. G.Vaidyanathan.
5. NPTEL Video Lectures on “Nuclear Science & Engineering” by Dr. Santanu Ghosh.
6. NPTEL Video Lectures on “Nuclear Reactor Technology” by Dr. K.S. Rajan
7. NPTEL Video Lectures on “Nuclear Physics: Fundamentals and Applications” by Prof. H.C.Verma

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	2	1	1	-	1	1	1	1	3	-	-	-
CO2	3	3	3	3	1	1	2	1	1	1	1	3	2	3	1
CO3	3	3	3	2	1	1	2	1	1	1	1	3	1	3	2
CO4	3	3	3	1	1	1	3	1	1	1	1	3	-	-	-
CO5	3	3	3	3	1	1	2	1	1	1	1	3	2	3	3
CO6	3	3	3	3	1	1	2	1	1	1	1	3	1	3	3
Avg.	3	3	2.8	2.33	1	1	1.83	1	1	1	1	3	1.5	3	2.2

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23029	FAULT DETECTION AND DIAGNOSIS	L	T	P	C
		3	0	0	3

UNIT – I INTRODUCTION & ANALYTICAL REDUNDANCY CONCEPTS 9L

Introduction – Types of faults and different tasks of Fault Diagnosis and Implementation – Different approaches to FDD: Model free and Model based approaches - Introduction- Mathematical representation of Faults and Disturbances: Additive and Multiplicative types – Residual Generation: Detection, Isolation, Computational and stability properties – Design of Residual generator – Residual specification and Implementation.

UNIT – II FAULT DETECTION AND DIAGNOSIS USING LIMIT CHECKING AND PROCESS IDENTIFICATION METHODS 9L

Limit Checking of absolute values – Trend Checking – Change detection using binary thresholds - adaptive thresholds – Change detection with Fuzzy thresholds – Fault detection using Process Identification methods and Principle Component Analysis.

UNIT – III FAULT DETECTION AND DIAGNOSIS USING PARITY EQUATIONS 9L

Introduction – Residual structure of single fault Isolation: Structural and Canonical structures - Residual structure of multiple fault Isolation: Diagonal and Full Row canonical concepts – Introduction to parity equation implementation and alternative representation – Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation.

UNIT – IV FAULT DIAGNOSIS USING STATE ESTIMATORS 9L

Introduction – Review of State Estimators – Fault Detection and Diagnosis using Generalized Likelihood Ratio Approach and Marginalized Likelihood Ratio Approach

UNIT – V CASE STUDIES 9L

Fault detection and diagnosis of DC Motor Drives – Fault detection and diagnosis of a Centrifugal pump-pipe system – Fault detection and diagnosis of an automotive suspension and the tire pressures - Automatic detection, quantification and compensation of valve stiction.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

1. Explain different approaches to Fault Detection and Diagnosis
2. Detect faults using Limit Checking, Parameter estimation methods, Principle Component Analysis.
3. Design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach.
4. Design and detect faults in sensor and actuators using GLR and MLR based approaches.
5. Detect and quantify and compensate stiction in Control valves.
6. Detect and diagnose the fault.

REFERENCES:

1. Janos J. Gertler, “Fault Detection and Diagnosis in Engineering systems”, 2nd Edition, MarcelDekker, 1998.
2. Rolf Isermann, “Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance”, Springer Verlag, 2006
3. Steven X. Ding, “Model based Fault Diagnosis Techniques: Schemes, Algorithms, and Tools”, Springer Publication, 2012.
4. Hassan Noura, Didier Theilliol, Jean-Christophe Ponsart and Abbas Chamseddine, “FaultTolerant Control Systems: Design and Practical Applications”, Springer Publication,2009.
5. Mogens Blanke, “Diagnosis and Fault-Tolerant Control”, Springer, 2006.
6. Ali Ahammad Shoukat Choudhury, Sirish L. Shah and Nina F. Thornhill, “Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches”, Springer, 2008.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	3	2	3	2	1	-	1	1	2	1	3	2	-	1
CO2	2	3	2	3	2	1	-	1	1	2	1	3	2	-	1
CO3	2	2	3	3	2	1	-	1	1	2	1	3	2	-	1
CO4	2	2	3	3	2	1	-	1	1	2	1	3	2	-	1
CO5	2	2	3	3	2	1	-	1	1	2	1	3	2	-	1
CO6	2	2	3	3	2	1	-	1	1	2	1	3	2	-	1
Avg.	2	2.6	2.8	3	2	1	-	1	1	2	1	3	2	-	1

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI2303 **PRODUCT CONCEPTUALIZATION AND PROTOTYPING**

L	T	P	C
3	0	0	3

UNIT – I **INTRODUCTION TO PRODUCT DESIGN & DEVELOPMENT** **9L**

Introduction – Characteristics of Successful Product Development – People involved in Product Design and Development - Duration and Cost of Product Development - The Challenges of Product Development - The Product Development Process - Concept Development - Product Development Process Flows - Product Development Organizations.

UNIT – II **OPPORTUNITY IDENTIFICATION & PRODUCT PLANNING** 9L

Opportunity Identification: Definition - Types of Opportunities - Tournament Structure of Opportunity Identification - Effective Opportunity Tournaments – Opportunity identification Process - Product Planning: Four Types of Product Development Projects - The Process of Product Planning.

UNIT – III **IDENTIFYING CUSTOMER NEEDS & PRODUCT SPECIFICATIONS** 9L

Identifying Customer Needs: The Importance of Latent Needs - The Process of Identifying Customer Needs. Product Specifications: Definition - Time of Specifications Establishment - Establishing Target Specifications - Setting the Final Specifications.

UNIT – IV **CONCEPT GENERATION & SELECTION** 9L

Concept Generation: Activity of Concept Generation - Structured Approach - Five step method of Concept Generation. Concept Selection: Methodology - Concept Screening and Concepts Scoring.

UNIT – V **CONCEPT TESTING & PROTOTYPING** 9L

Concept Testing: Seven Step activities of concept testing. Prototyping – Principles of Prototyping – Prototyping Technologies – Planning for Prototypes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Recall the principles of generic development process; and understand the organization structure for new product design and development. (L1)
2. Build the plan for new product design and development. (L3)
3. Compile customer need analysis; and set product specification for new product design and development. (L5,L6)
4. Generate, select, and screen the concepts for new product design and development. (L4)
5. Explain concepts to design and develop new products. (L2)

REFERENCES:

1. Ulrich K.T., Eppinger S. D. and Anita Goyal, “Product Design and Development “McGraw-Hill Education; 7th edition,2020.
2. Belz A., 36-Hour Course: “Product Development”, McGraw-Hill,2010.
3. Rosenthal S., “Effective Product Design and Development”, Business One Orwin, Home wood, 1992, ISBN 1-55623-603-4.

4. Stuart Pugh., "Total Design –Integrated Methods for Successful Product Engineering", Addison Wesley Publishing, 1991, ISBN 0-202-41639-5.
5. Chitale, A. K. and Gupta, R. C., Product Design and Manufacturing, PHI Learning, 2013.
6. Jamnia, A., Introduction to Product Design and Development for Engineers, CRC Press, 2018.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	-	-	-	-	-	1	-	1	-	-	-	-	-
CO2	-	-	-	-	3	-	-	1	3	1	-	3	-	-	-
CO3	-	-	3		3	-	-	1	3	1	-	3	-	2	-
CO4	-	2	-	-		-	3	1	-	1	-	3	3	-	-
CO5	-	-	-	-	3	-	-	1	3	1	-	3	-	-	-
Avg.	3	2.5	3	-	-	-	3	1	3	1	-	3	3	2	-

1 - low, 2-medium, 3-high, '-"- no correlation

VERTICAL V - HEALTH CARE INSTRUMENTATION

EI23031	BIOMEDICAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

UNIT – I BASIC CONCEPTS OF MEDICAL INSTRUMENTATION 9L

Terminology of medicine and medical devices – Generalized medical Instrumentation systems – Classification of Biomedical instruments – Medical measurement constraints – Interfering and modifying inputs – Compensation Techniques – Classification of transducers, selecting of transducers – The origin of Bio-potentials – Electrical activity of excitable cells – Bio-potential Electrodes: The electrode-Electrolyte interface, Polarization: Polarizable and non-polarizable electrodes, Electrode behavior and circuit models, Surface, Needle and Microelectrodes.

UNIT – II ELECTRICAL PARAMETERS ACQUISITION AND ANALYSIS 9L

Types and Classification of biological signals – Cardiac Cycle, Electrocardiography, waveform and measurement, Einthoven‘s Triangle, Twelve Lead System – cardiac stress test. EEG – 10-20 electrode system, unipolar, bipolar and average mode. Electrogastrography, Electroretinography- Electromyography and Nerve Conduction Velocity. Patient safety, electrical shocks and hazards, leakage currents, types & measurements, protection against shock, burn & explosion hazards -Radiation safety requirements.

UNIT – III NON-ELECTRICAL PARAMETERS MEASUREMENT AND DIAGNOSTIC PROCEDURES 9L

Measurement of blood pressure – Cardiac output – Blood flow – Heart rate – Heart sound – Pulmonary function measurements – Spirometer – Photo Plethysmography, Body Plethysmography – Blood Gas analyzers, pH of blood – Measurement of blood pCO2, pO2, finger-tip oximeter –GSR measurements.

UNIT – IV MEDICAL IMAGING SYSTEMS 9L

Computer tomography – Magnetic resonance imaging - Functional MRI -– Nuclear medicine – Single photo emission computer tomography – Positron emission tomography – Ultrasonography – Doppler Ultra sound and Colour flow mapping –– Digital subtraction angiography (DSA). Endoscopy -Thermography - Optical coherence tomography (OCT): Introduction and its medical applications - Advances in image resolutions and speed in picture archiving and communication systems (PACS) in medical imaging.

UNIT – V LIFE ASSISTING AND THERAPEUTIC DEVICES 9L

Pacemakers – Defibrillators – Ventilators – Nerve and muscle stimulators – Diathermy – Endoscopy -Heart – Lung machine – Audio meters – Dialyzers – Lithotripsy – Artificial limb and hands, prosthetic heart valves. Infant Incubators – Drug Delivery Devices – Surgical Instruments.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain the operation of different medical devices. (L2)
2. Analyze the Biological signals. (L4)

3. Demonstrate the working of medical instruments in diagnosis, therapeutic treatment and imaging fields. (L2)
4. Design the circuits for biomedical instruments. (L5)
5. Explain simple bio sensing and transduction problems (L1)
6. Apply the safety procedures and select disposal method, procedures for electrical diagnostic equipment. (L3)

REFERENCES:

1. John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, 4th Edition New York, 2009.
2. Leslie Cromwell, "Biomedical Instrumentation and Measurement", Prentice Hall of India, New Delhi, 2007.
3. James E. Moore Jr, Duncan J. Maitland ,"Biomedical Technology and Devices", CRC press, 2nd Edition 2013.
4. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, 3rd Edition, New Delhi, 2014.
5. Ed. Joseph D. Bronzino, "The Biomedical Engineering Hand Book", 2nd Edition, Boca Raton, CRC Press LLC, 2000.
6. Joseph J. Carr and John M. Brown," Introduction to Biomedical Equipment Technology", John Wiley and sons, 4th Edition, New York, 2000.
7. Suh, Sang, Gurupur, Varadraj P., Tanik, Murat M., "Health Care Systems, Technology and Techniques", Springer, 1st Edition, 2011.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	-	3	3	3	1	2	2	2	2	3	3	-	-
CO2	3	2	3	3	3	2	2	-	1	-	-	1	3	1	-
CO3	3	3	1	3	3	3	2	2	2	1	1	3	2	1	-
CO4	3	3	1	3	3	3	2	2	2	1	1	3	3	1	-
CO5	2	3	2	3	2	1	-	-	-	-	-	1	2	-	-
CO6	1	1	1	1	3	3	3	3	1	-	1	3	2	-	-
Avg.	2.3	2.3	1.6	2.7	2.8	2.5	2	2.25	1.6	1.3	1.25	2.3	2.5	1	-

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23032	MEDICAL IMAGING EQUIPMENT	L	T	P	C
		3	0	0	3

UNIT – I X RAYS 9L

Nature of X-rays- X-Ray absorption – Tissue contrast. X- Ray Equipment (Block Diagram) – X-Ray Tube, the collimator, Bucky Grid, power supply, Digital Radiography - discrete digital detectors, storage phosphor and film scanning, X-ray Image Intensifier tubes – Fluoroscopy – Digital Fluoroscopy. Angiography, cine Angiography. Digital subtraction Angiography. Mammography

UNIT – II COMPUTED TOMOGRAPHY 9L

Principles of tomography, CT Generations, X- Ray sources- collimation- X- Ray detectors – Viewing systems – spiral CT scanning – Ultra fast CT scanners. Image reconstruction techniques – back projection and iterative method.

UNIT – III MAGNETIC RESONANCE IMAGING 9L

Fundamentals of magnetic resonance- properties of electromagnetic waves : speed , amplitude, phase, orientation and waves in matter - Interaction of Nuclei with static magnetic field and Radio frequency wave- rotation and precession – Induction of magnetic resonance signals – bulk magnetization – Relaxation processes T1 and T2. Block Diagram approach of MRI system – system magnet (Permanent, Electromagnet and Superconductors), generations of gradient magnetic fields, Radio Frequency coils (sending and receiving), shim coils, Electronic components, fMRI.

UNIT – IV NUCLEAR IMAGING 9L

Radioisotopes- alpha, beta, and gamma radiations. Radio Pharmaceuticals. Radiation detectors –gas filled, ionization chambers, proportional counter, GM counter and scintillation Detectors, Gamma camera – Principle of operation, collimator, and photomultiplier tube, X-Y positioning circuit, pulse height analyzer. Principles of SPECT and PET.

UNIT – V RADIATION THERAPY AND RADIATION SAFETY 9L

Radiation therapy – linear accelerator, Telegamma Machine. SRS – SRT – Recent Techniques in radiation therapy – 3D CRT – IMRT – IGRT and Cyber knife – radiation measuring instruments Dosimeter, film badges, Thermo Luminescent dosimeters – electronic dosimeter – Radiation protection in medicine – radiation protection principles.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Describe the working principle of medical imaging equipments. (L1)
2. Illustrate the principles of nuclear and non-nuclear imaging techniques. (L2)
3. Select the technique used for visualizing various sections of the body for diagnosis. (L3)
4. Demonstrate the applications of medical imaging. (L2)
5. Analyze different imaging techniques and choose appropriate imaging equipment considering radiation safety. (L4)

REFERENCES:

1. Isaac Bankman, I. N. Bankman, Handbook of Medical Imaging: Processing and Analysis(Biomedical Engineering),Academic Press,2000.
2. Jacob Beutel (Editor), M. Sonka (Editor), Handbook of Medical Imaging, Volume 2. Medical Image Processing and Analysis, SPIE Press 2000.
3. Khin Wee Lai, DyahEkashantiOctorinaDewi "Medical Imaging Technology", Springer Singapore, 2015.
4. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw – Hill, New Delhi, 2003.
5. Dougherty, Geoff (Ed.), "Medical Image Processing - Techniques and Applications", Springer-Verlag New York, 2011.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	1	2	-	-	-	-	-	-	-	1	-	1
CO2	3	2	1	1	2	-	-	-	-	-	-	-	1	-	1
CO3	3	2	1	1	2	-	-	-	-	-	-	-	1	-	1
CO4	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1
CO5	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1
Avg.	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23033 **DIAGNOSTIC AND THERAPEUTIC INSTRUMENTATION**

L	T	P	C
3	0	0	3

UNIT – I CARDIAC EQUIPMENT 9L

Electrocardiograph, Normal and Abnormal Waves, Heart rate monitor, Holter Monitor, Phonocardiography, ECG machine maintenance and troubleshooting, Cardiac Pacemaker- Internal and External Pacemaker– Batteries, AC and DC Defibrillator- Internal and External, Defibrillator Protection Circuit, Cardiac ablation catheter.

UNIT – II NEUROLOGICAL EQUIPMENT 9L

Clinical significance of EEG, Multi-channel EEG recording system, Epilepsy, Evoked Potential– Visual, Auditory and Somatosensory, MEG (Magneto Encephalo Graph). EEG Bio Feedback Instrumentation. EEG system maintenance and troubleshooting**.**

UNIT – III MUSCULAR AND BIOMECHANICAL EQUIPMENT 9L

Recording and analysis of EMG waveforms, fatigue characteristics, Muscle stimulators, nerve stimulators, Nerve conduction velocity measurement, EMG Bio Feedback Instrumentation. Static Measurement – Load Cell, Pedobarograph. Dynamic Measurement – Velocity, Acceleration, GAIT, Limb position.

UNIT – IV RESPIRATORY MEASUREMENT AND ASSIST SYSTEM 9L

Instrumentation for measuring the mechanics of breathing – Spirometer -Lung Volume and vital capacity, measurements of residual volume, Pneumotachometer – Airway resistance measurement, Whole body Plethysmograph, Intra-Alveolar and Thoracic pressure measurements, Apnoea Monitor. Types of Ventilators – Pressure, Volume, and Time controlled. Flow, Patient Cycle Ventilators, Humidifiers, Nebulizers, Inhalators.

UNIT – V SENSORY DIAGNOSTIC EQUIPMENT 9L

Psychophysiological Measurements – polygraph, basal skin resistance (BSR), galvanic skin resistance (GSR), Sensory responses - Audiometer-Pure tone, Speech, Eye Tonometer, Applanation Tonometer, slit lamp, auto refractometer

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Describe the working and recording setup of all basic diagnostic and therapeutic equipment. (L2)
2. Design of recording instruments of all basic equipment. (L4)
3. Select the proper diagnostic and therapeutic equipment. (L2)
4. Analyze the parameters related to physiological systems. (L3)
5. Select and explain the measurement techniques of sensory responses. (L1, L3)

REFERENCES:

1. John G. Webster, “Medical Instrumentation Application and Design”, 4th edition, Wiley India Pvt. Ltd., New Delhi, 2015.
2. Joseph J. Carr and John M. Brown, “Introduction to Biomedical Equipment Technology”, Pearson education, 2012.

3. L.A Geddes and L.E.Baker, “Principles of Applied Biomedical Instrumentation”, 3rd Edition, 2008.
4. Khandpur. R.S.,“Handbook of Biomedical Instrumentation”. Second Edition. Tata McGraw Hill Pub. Co., Ltd. 2003.
5. Antony Y.K.Chan,”Biomedical Device Technology, Principles and design”, Charles Thomas Publisher Ltd, Illinois, USA, 2008.
6. Leslie Cromwell, “Biomedical Instrumentation and Measurement”, Pearson Education, New Delhi, 2007.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	-	1	-	-	-	-	-	-	1	2	-	1
CO2	3	2	1	-	1	-	-	-	-	-	-	1	2	-	1
CO3	3	2	1	-	1	-	-	-	-	-	-	1	2	-	1
CO4	3	2	1	-	1	-	-	-	-	-	-	1	2	-	1
CO5	3	2	1	-	1	-	-	-	-	-	-	1	2	-	1
Avg.	3	2	1	-	1	-	-	-	-	-	-	1	2	-	1

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23034 **BIOSIGNAL ANALYSIS**

L	T	P	C
3	0	0	3

UNIT – I BIOSIGNAL AND SPECTRAL CHARACTERISTICS 9L

Characteristics of some dynamic biomedical signals, Noises- random, structured and physiological noises. Filters- IIR and FIR filters. Spectrum – power spectral density function, cross-spectral density and coherence function, cepstrum and homomorphic filtering. Estimation of mean of finite time signals.

UNIT – II TIME SERIES ANALYSIS AND SPECTRAL ESTIMATION 9L

Time series analysis – linear prediction models, process order estimation, lattice representation, non-stationary process, fixed segmentation, adaptive segmentation, application in EEG, PCG signals, Time varying analysis of Heart-rate variability, model-based ECG simulator. Spectral estimation –Blackman Tukey method, periodogram, and model-based estimation. Application in Heart rate variability, PCG signals.

UNIT – III ADAPTIVE FILTERING AND WAVELET DETECTION 9L

Filtering – LMS adaptive filter, adaptive noise canceling in ECG, improved adaptive filtering in ECG, Wavelet detection in ECG – structural features, matched filtering, adaptive wavelet detection, detection of overlapping wavelets.

UNIT – IV BIOSIGNAL CLASSIFICATION AND RECOGNITION 9L

Signal classification and recognition – Statistical signal classification, linear discriminant function, direct feature selection and ordering, Back propagation neural network-based classification. Application in Normal versus Ectopic ECG beats.

UNIT – V TIME FREQUENCY AND MULTIVARIATE ANALYSIS 9L

Time frequency representation, spectrogram, Wigner distribution, Time-scale representation, scalogram, wavelet analysis – Data reduction techniques, ECG data compression, ECG characterization, Feature extraction- Wavelet packets, Multivariate component analysis-PCA,ICA.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain the preprocessing methods of biosignals. (L1)
2. Analyze bio signals in time domain & to estimate the spectrum. (L4)
3. Apply different techniques for bio signal processing. (L3)
4. Classify bio signals using neural networks and statistical classifiers. (L2)
5. Estimate the features using different tools. (L5)

REFERENCES:

1. Rangaraj M. Rangayyan, “Biomedical Signal Analysis-A case study approach”,
2. Wiley, 2nd Edition, 2016.
3. Willis J. Tompkins, “Biomedical Digital Signal Processing”, Prentice Hall of India, New Delhi, 2003.
4. Arnon Cohen, “Bio-Medical Signal Processing Vol I and Vol II”, CRC Press Inc., Boca Rato, Florida, 1999.

5. Kayvan Najarian and Robert Splerstor, “Biomedical signals and Imageprocessing’’, CRC – Taylor and Francis, New York, 2nd Edition, 2012.
6. K.P.Soman, K.Ramachandran, “Insight into wavelet from theory to practice”, PHI, New Delhi, 3rd Edition, 2010.
7. D.C.Reddy, “Biomedical Signal Processing – Principles and Techniques’’, Tata McGraw-Hill Publishing Co. Ltd, 2005.
8. John L.Semmlow, “Biosignal and Biomedical Image Processing Matlab Based applications’’, Taylor& Francis Inc, 2004.

MAPPING OF COs WITH POs AND PSOs

CO’s	**PO’s**												**PSO’s**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	1	1	1	-	-	-	-	-	-	-	1	-	-
CO2	3	1	1	1	1	-	-	-	-	-	-	-	1	-	-
CO3	3	1	1	1	1	-	-	-	-	-	-	-	1	-	-
CO4	3	1	1	1	1	-	-	-	-	-	-	-	1	-	-
CO5	3	1	1	1	1	-	-	-	-	-	-	-	1	-	-
Avg.	3	1	1	1	1	-	-	-	-	-	-	-	1	-	-

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23035 **BIOMEDICAL IMAGE PROCESSING**

L	T	P	C
3	0	0	3

UNIT – I FUNDAMENTALS OF IMAGE PROCESSING 9L

Image perception, MTF of the visual system, Image fidelity criteria, Image model, Image sampling and quantization – two-dimensional sampling theory, Image quantization, Optimum mean square quantizer, Image transforms – 2D-DFT and other transforms.

UNIT – II BIO-MEDICAL IMAGE PREPROCESSING 9L

Image Enhancement operations – Image noise and modeling, Image restoration – Image degradation model, Inverse and Wiener filtering, Geometric transformations and correction.

UNIT – III MEDICAL IMAGE RECONSTRUCTION 9L

Mathematical preliminaries and basic reconstruction methods, Image reconstruction in CT scanners, MRI, fMRI, Ultrasound imaging. 3D Ultrasound imaging, Nuclear Medical Imaging modalities – SPECT, PET, Molecular Imaging.

UNIT – IV IMAGE ANALYSIS AND CLASSIFICATION 9L

Image segmentation- pixel based, edge based, region-based segmentation. Active contour models and Level sets for medical image segmentation, Image representation and analysis, Feature Extraction and Representation-Statistical, Shape, Texture features. Statistical and Neural Network based image classification.

UNIT – V IMAGE REGISTRATIONS AND VISUALIZATION 9L

Image Registration: Rigid body transformation – Affine transformation, Principal axes registration, Iterative principal axes registration, Feature based registration, Elastic deformation-based registration, Registration of Images from Different modalities, Evaluation of Registration Methods. Image visualization: 2-D display methods, 3-D display methods, surface and volume based 3-D display methods – Surface Visualization and Volume visualization, 3-D Echocardiography, 3D+time Echocardiography, virtual reality based interactive visualization.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain basic medical image processing algorithms. (L1)
2. Choose suitable image pre-processing techniques that incorporates different concepts of filters for medical Image Processing (L3)
3. Elucidate medical imaging and reconstruction techniques. (L2)
4. Analysis of image segmentation, feature extraction and image classification. (L4)
5. Applying Image processing concepts in medical images. (L3)

REFERENCES:

1. AtomP.Dhawan, Medical Image Analysis, 2nd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2011.
2. Rafael C.Gonzalez and Richard E.Woods, Digital Image Processing, 4thEdition, Pearson Education, 2018.

3. Anil K Jain, Fundamentals of Digital Image Processing, 1stEdition, Pearson Education India, 2015.
4. Geoff Dougherty, Digital Image Processing for Medical Applications, 1st Edition, Cambridge University Press, 2010.
5. Jerry L.Prince and Jonathan M.Links, Medical Imaging Signals and Systems, 2nd Edition, Pearson Education, 2014.
6. Kavyan Najarian and Robert Splerstor, Biomedical signals and Image processing, 2nd Edition, CRC Press, 2012.
7. Ravikanth Malladi, Geometric Methods in Bio-Medical Image Processing (Mathematics and Visualization), 1st Edition, Springer-Verlag Berlin Heidelberg 2002.
8. A. Ardeshir Goshtasby, Image Registration Principles, Tools and Methods (Advances in Computer Vision and Pattern Recognition), Springer 2014.
9. Joseph V. Hajnal, Derek L.G. Hill and David J. Hawkes, Medical Image Registration, CRC Press, 2001.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	-	-	1	-	2	-	-	-	-	-	1	-
CO2	3	3	1	-	-	1	-	2	-	-	-	-	-	1	-
CO3	3	3	1	-	-	1	-	2	-	-	-	-	-	1	-
CO4	3	3	3	2	-	1	-	2	-	-	-	-	-	1	-
CO5	3	3	3	-	-	1	-	2	-	-	-	-	-	1	-
Avg.	3	2.8	1.8	2	-	1	-	2	-	-	-	-	-	1	-

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23036 **PHYSIOLOGICAL CONTROL SYSTEMS**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION TO PHYSIOLOGY AND PHYSIOLOGICAL CONTROL SYSTEMS **9L**

Introduction to Human Physiology - Analysis of Physiological Control Systems- Difference between engineering and physiological control systems.

UNIT – II STATIC ANALYSIS OF PHYSIOLOGICAL SYSTEMS 9L

Open loop and Closed loop systems- Steady state analysis- Regulation of Cardiac Output-Regulation of Glucose- Chemical regulation of ventilation.

UNIT – III TIME FREQUENCY DOMAIN ANALYSIS OF LINEAR PHYSIOLOGICAL CONTROL SYSTEMS 9L

Linearized respiratory mechanics- Open loop and Closed loop transient responses- First order and second order models- Impulse and Step response descriptors- Open and closed loop dynamics-Graphical representations of frequency response- Frequency response of Glucose- Insulin regulation and Circulatory Control Model.

UNIT – IV NON-LINEAR ANALYSIS OF PHYSIOLOGICAL CONTROL SYSTEM 9L

Difference between linear and non-linear systems- The Hodgkin-Huxley model - van der Pol model of Neuronal dynamics - Spontaneous Variability- Delayed feedback Nonlinear Control systems-Coupled non-linear Oscillators- Time-varying Physiological closed loop systems- Sleep Apnea model.

UNIT – V CASE STUDIES AND SIMULATION 9L

Simulation of cardiovascular variability (stroke volume constant and stroke volume variable)-Simulation of glucose- insulin regulation (Stolwijk and Hardy model)-Simulation of neuromuscular reflex model -Simulation of patient- ventilator system-Simulation of respiratory sinus arrhythmia (Saul model).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Ability to:

1. Understand the basic principles of human physiology and differentiate between engineering and physiological control systems.
2. Perform static analysis of physiological systems, including open loop and closed loop systems.
3. Apply time frequency domain analysis to linear physiological control systems.
4. Analyze linear and non-linear physiological control systems.
5. Perform simulation of various physiological control systems including cardiovascular variability, glucose-insulin regulation, neuromuscular reflex models, patient-ventilator systems, and respiratory sinus arrhythmia.
6. Understand the practical implications and applications of physiological models in medical and biomedical engineering contexts.

REFERENCES:

1. Michael. C. K. Khoo, Physiological Control Systems, IEEE Press, Ed., Robert. S. Herrick, Prentice – Hall of India, New Delhi, 2001.
2. Milhorn, H. T., The Application of Control theory to Physiological Systems, Saunders, W. B., Philadelphia, 1996.
3. Kuo, B. C., Automatic Control Systems, 4th ed., Prentice- Hall, Englewood Cliffs, NJ, 1994.
4. Dorf, R. C. and Bishop, R. H., Modern Control Systems, 7th ed., Addison- Wesley Reading, MA, 1995.
5. Thompson, J. M. T. and Stewart, H. B., Nonlinear dynamics and chaos, Wiley, New York, 1986.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	2	2	-	-	-	1	3	2	-	-	-	-	-
CO 2	3	-	1	-	-	-	-	2	-	-	-	1	1	-	-
CO 3	3	2	-	-	-	-	-	-	3	2	-	3	2	-	-
CO 4	3	-	3	3	-	2	1	1	3	2	-	1	3	2	3
CO 5	3	-	-	-	-	-	-	-	2	2	-	2	-	-	3
CO 6	3	3	3	3	-	2	1	-	3	2	-	-	2	-	3
Avg.	3	2.3	2.25	2.6	-	2	1	1.3	3	2	-	1.75	2	2	3

1 - Low, 2-medium, 3-high, '-"- no correlation

EI23037 **REHABLITATION INSTRUMENTATION**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION TO REHABILITATION 9L

Definition - Impairments, disabilities and handicaps, Primary and secondary disabilities, Activities of daily living, Appropriate Technology, Residual function. Rehabilitation. Rehabilitation team – members and their functions. Rehabilitation care –Need for proper delivery of rehabilitation care, Community based rehabilitation and its aspects.

UNIT – II ENGINEERING CONCEPTS IN SENSORY AUGMENTATION AND SUBSTITUTION 9L

Sensory augmentation and substitution- Visual system: Visual augmentation, Tactual vision substitution, and Auditory vision substitution. Auditory system- Auditory augmentation, Hearing aids, cochlear implants, visual auditory substitution, tactual auditory substitution. Tactual system - Tactual augmentation, Tactual substitution.

UNIT – III ORTHOPEDIC PROSTHETICS AND ORTHOTICS 9L

Engineering concepts in motor rehabilitation, Artificial limbs- body powered, externally powered and controlled orthotics and prosthetics, Myoelectric hand and arm prosthetics. Functional Electrical Stimulation systems-Restoration of hand function, restoration of standing and walking, Hybrid Assistive Systems (HAS).

UNIT – IV VIRTUAL REALITY 9L

Introduction to virtual reality, Virtual reality based rehabilitation, Hand motor recovery systems with Phantom haptics, Robotics and Virtual Reality Applications in Mobility Rehabilitation.

UNIT – V REHABILITATION MEDICINE AND ADVOCACY 9L

Physiological aspects of Function recovery, Psychological aspects of Rehabilitation therapy, Legal aspect available in choosing the device and provision available in education, job and in day-to-day life.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Summarize the key terminologies used by the rehabilitation team.
2. Illustrate Engineering Concepts in Sensory & Motor rehabilitation.
3. Design different orthotics and prosthetics for rehabilitation applications.
4. Summarize the need of virtual reality tools for different aids.
5. Appraise the legal aspects for building rehabilitation aids for the needed people.

REFERENCES:

1. Joseph D Bronzino, “The Biomedical Engineering Handbook”. 2nd edition, CRC Press, 2000.
2. Robinson C.J, “Rehabilitation Engineering”, CRC Press, 2006.
3. Horia- Nocholai Teodorecu, L.C.Jain, “Intelligent systems and technologies in rehabilitation Engineering”, CRC; December 2000
4. Sashi S Kommu, “Rehabilitation Robotics”, 1st edition, CRC Press, 2007.
5. Etienne Grandjean, Harold Oldroyd, “Fitting the task to the man”, Taylor & Francis, 1988

6. Keswick. J., “What is Rehabilitation Engineering, Annual Reviews of Rehabilitation”, Springer Verlag, New York, 1982.
7. Warren E. Finn, Peter G. Lopressor, “Handbook of Neuroprosthetic Methods”,CRC, 2002
8. Roy A Cooper (Editor), Hisaichi Ohnabe (Editor), Douglas A. Hobson (Editor), “An Introduction to Rehabilitation Engineering (Series in Medical Physics and Biomedical Engineering” CRC Press, 2000

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	1	-	-	1	-	1	-	-	-	-	1	-	-
CO2	3	1	1	-	-	1	-	1	-	-	-	-	1	-	-
CO3	3	1	1	-	-	1	-	1	-	-	-	-	1	-	-
CO4	3	1	1	-	-	1	-	1	-	-	-	-	1	-	-
CO5	3	1	1	-	-	1	-	1	-	-	-	-	1	-	-
Avg.	3	1	1	-	-	1	-	1	-	-	-	-	1	-	-

1-Low, 2-Medium, 3-High, ‘-“- no correlation

VERTICAL VI- SEMICONDUCTOR TECHNOLOGY AND APPLICATIONS

EI23038	VLSI TECHNOLOGY	L	T	P	C
		3	0	0	3

UNIT – I MOS TRANSISTOR PRINCIPLES 9L

MOS Technology and VLSI, Pass transistors, NMOS, CMOS Fabrication process and Electrical properties of CMOS circuits and Device modelling. Characteristics of CMOS inverter, Scaling principles and fundamental limits. Propagation Delays, CMOS inverter scaling, Stick diagram, Layout diagrams, Elmore's constant, Logical Effort. Case study: Study of technology development in MOS.

UNIT – II COMBINATIONAL LOGIC CIRCUITS 9L

Static CMOS logic Design, Design techniques to improve the speed, power dissipation of CMOS logic, low power circuit techniques, Ratioed logic, Pass transistor Logic, Transmission CPL, DCVSL, Dynamic CMOS logic, Domino logic, Dual Rail logic, NP CMOS logic and NORA logic.

UNIT – III SEQUENTIAL LOGIC CIRCUITS 9L

Static and Dynamic Latches and Registers, Timing Issues, Pipelines, Clocking strategies, Memory Architectures, and Memory control circuits.

UNIT – IV DESIGNING ARITHMETIC BUILDING BLOCKS & TESTING 9L

Data path circuits, Architectures for Adders, Accumulators, Multipliers, Barrel Shifters, Need for testing- Manufacturing test principles- Design for testability. Case study: Analysis of area, power and delay for 16-bit adder and 8-bit multiplier.

UNIT – V IMPLEMENTATION STRATEGIES 9L

Full Custom and Semicustom Design, Standard Cell design and cell libraries, FPGA building block architectures, FPGA interconnect routing procedures. Demo: Complete ASIC flow using Backend tool and fabrication flow Overall case study: Development of IC in commercial aspects (design, testing and fabrication cost).

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Interpretation of Data Sheet of transistors and ICs with respect to their Static and Dynamic Characteristics.
2. Familiarization of any one relevant software tool (MATLAB/ SCILAB/ LABVIEW/ Proteus/ Equivalent open-source software)
3. Design and verification of simple signal conditioning circuit thro simulation.
4. Realization of signal conditioning circuit in hardware Introduction to other advanced logic circuits not covered in the above syllabus

COURSE OUTCOMES:

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

1. Relate characteristics and realize modeling of MOS transistors. (L1)
2. Explain the design combinational logic using various logic styles, satisfying static and dynamic requirements (L2)
3. Apply timing issues of sequential logic and design memories. (L3)
4. Analyse and design data path elements (L4)
5. Build FPGA architecture and interconnect methodology (L3)

REFERENCES:

1. Jan Rabaey, Anantha Chandrakasan, B.Nikolic, “Digital Integrated circuits: A Design Perspective”, Prentice Hall of India, 2nd Edition, 2003.
2. N.Weste, K.Eshraghian, “Principles of CMOS VLSI DESIGN”, A system Perspective, 2nd Edition, Addison Wesley, 2004.
3. A.Pucknell, Kamran Eshraghian, “BASIC VLSI DESIGN”, Prentice Hall of India, 3rd Edition, 2007.
4. M.J. Smith, “Application Specific Integrated Circuits”, Addisson Wesley, 1997.
5. R.Jacob Baker, Harry W.LI., David E.Boyee, “CMOS Circuit Design, Layout and Simulation”, Prentice Hall of India, 2005.

List of Open-Source Software/ Learning website:

1. https://lecturenotes.in/subject/1159/digital-vlsi
2. https://edurev.in/studytube/Digital-VLSI-design--Lecture-Notes--ECE--Engineeri/7565abc5-b92d-4f7b-bc7c-6e029807cdab_p
3. https://nptel.ac.in/courses/117103066
4. https://nptel.ac.in/courses/117106086
5. https://archive.nptel.ac.in/courses/117/101/117101004/

MAPPING OF CO’S WITH PO’S AND PSO’S

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	1	1	1	-	-	-	1	-	1	-	-	-	2	-
CO2	2	2	1	2	-	-	-	1	-	1	-	-	-	2	-
CO3	3	2	2	2	-	-	-	1	-	1	-	-	-	2	-
CO4	3	3	3	2	-	-	-	1	-	1	-	-	-	2	-
CO5	3	2	2	2	-	-	-	1	-	1	-	-	-	2	-
Avg.	2	1.7	1.5	1.5	-	-	-	1	-	1	-	-	-	2	-

1-low, 2-medium, 3-high, ‘-‘ - no correlation

EI23039 **REALTIME EMBEDDED SYSTEMS**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS **9L**

Complex systems and microprocessors – Embedded system design process – Formalism for system design – Design example: Model train controller - ARM Processor Fundamentals-Instruction Set and Programming using ARM Processor.

UNIT – II COMPUTING PLATFORM 9L

CPU: Programming input and output – Supervisor mode, exception and traps – Coprocessor – Memory system mechanism – CPU performance – CPU power consumption- CPU buses – Memory devices – I/O devices – Component interfacing- System Level Performance Analysis-Parallelism. Design Example: Data Compressor.

UNIT – III PROGRAM DESIGN AND ANALYSIS 9L

Program design – Model of programs – Assembly and Linking – Basic compilation techniques – Program Optimization- Analysis and optimization of execution time, power, energy, program size – Program validation and testing- Example: Software Modem.

UNIT – IV PROCESS AND OPERATING SYSTEMS 9L

Multiple tasks and Multicore processes – Processes – Context Switching – Operating Systems – Priority based Scheduling- RMS and EDF - Inter Process Communication mechanisms – Evaluating operating system performance – Power optimization strategies for processes.

UNIT – V HARDWARE ACCELERATORS & NETWORKS 9L

Multiprocessors- CPUs and Accelerators – Performance Analysis- Distributed Embedded Architecture – Networks for Embedded Systems: - I2C, CAN Bus, Ethernet, Myrinet – Network based design – Internet enabled systems. Design Example: Elevator Controller.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Interpretation of Processors.
2. Selection of Processor for applications.
3. Familiarization of any one relevant software tool (MATLAB/ SCILAB/ LABVIEW/ Proteus/ Equivalent open-source software)
4. Design and verification of simple signal conditioning circuit thro simulation.
5. Realization of signal conditioning circuit in hardware
6. Introduction to other advanced Processors not covered in the above syllabus

COURSE OUTCOMES:

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

1. Design and develop ARM processor-based systems. (L5)
2. Explain role of microcontrollers in embedded systems. (L2)
3. Apply program design and optimization and proper scheduling of the process. (L3)
4. Analyze the concept of process, multi processes and operating systems in embedded system design. (L4)
5. Build various communication protocols in distributed embedded computing platform. (L3)

REFERENCES:

1. Wayne Wolf, "Computers as Components - Principles of Embedded Computing System Design", Morgan Kaufmann Publisher (An imprint of Elsevier), 3rd Edition, 2008.
2. Andrew N Sloss, Dominic Symes, Chris Wright, "ARM System Developer‘s Guide-Designing and Optimizing System Software", Elsevier/Morgan Kaufmann Publisher, 2008.
3. David E-Simon, "An Embedded Software Prime", Pearson Education, 2010.
4. Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2006.
5. Jane.W.S. Liu, "Real-Time Systems", Pearson Education Asia, 2011.

List of Open-Source Software/ Learning website:

1. https://nptel.ac.in/courses/117106111
2. https://onlinecourses.nptel.ac.in/noc20_cs16/preview
3. https://archive.nptel.ac.in/courses/108/105/108105057/
4. https://mrcet.com/downloads/digital_notes/ECE/IV%20Year/EMBEDDED%20SYSTEMS%20DESIGN.pdf
   https://nptel.ac.in/courses/117106112

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	3	-	-	-	1	-	1	-	-	-	3	-
CO2	2	2	1	2	-	-	-	1	-	1	-	-	-	3	-
CO3	3	2	2	2	-	-	-	1	-	1	-	-	-	3	-
CO4	3	3	3	2	-	-	-	1	-	1	-	-	-	3	-
CO5	3	2	2	2	-	-	-	1	-	1	-	-	-	3	-
Avg.	2.8	2.4	2.2	2.2	-	-	-	1	-	1	-	-	-	3	-

1-low, 2-medium, 3-high, ‘-“- no correlation

EI23040	SEMICONDUCTOR DEVICE MANUFACTURING	L	T	P	C
		3	0	0	3

UNIT – I INTRODUCTION TO SEMICONDUCTOR MANUFACTURING 9L

Historical perspective, processing overview, semiconductor materials, semiconductor devices, process technology, fabrication steps.

UNIT – II MANUFACTURING PROCESS: CRYSTAL GROWTH, SILICON OXIDATION, PHOTOLITHOGRAPHY 9L

Silicon crystal growth, material characterization, thermal oxidation process, impurity redistribution, masking properties of silicon dioxide, oxidation thickness characteristics.

UNIT – III MANUFACTURING PROCESS: ETCHING, DIFFUSION, ION IMPLANTATION, FILM DEPOSITION 9L

Wet chemical etching, Dry etching, basic diffusion process, extrinsic diffusion, lateral diffusion, Photolithography, Ion Implantation, implanted damage and annealing, epitaxial growth techniques, structures and defects, dielectric deposition, metallization.

UNIT – IV PROCESS INTEGRATION 9L

Passive components, bipolar technology, MOSFET Technology, MESFET Technology, MEMS Technology.

UNIT – V IC MANUFACTURING 9L

Electrical testing, packing, statistical process control, computer integrated manufacturing, challenges for integration, system-on-a-chip.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Interpretation of Data Sheet of transistors and ICs with respect to their Static and Dynamic Characteristics.
2. Familiarization of any one relevant software tool (MATLAB/ SCILAB/ LABVIEW/ Proteus/ Equivalent open-source software).
3. Design and verification of simple signal conditioning circuit through simulation.
4. Realization of signal conditioning circuit in hardware.
5. Introduction to other advanced logic circuits not covered in the above syllabus.

COURSE OUTCOMES:

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

1. Relate technology changes from semiconductor manufacturing industry.(L2)
2. Explain steps for making silicon wafers from sand.(L1)
3. Apply various technology involved in manufacturing.(L3)
4. Analyze the integration of steps in CMOS IC chip fabrication.(L4)
5. Build CMOS-based used in the electronics industry.(L5)

REFERENCES:

1. G. S. May and S. M. Sze, Fundamentals of Semiconductor Fabrication, Wiley India, 2004.

2. Hong Xiao, Introduction to Semiconductor Manufacturing Technology – Second Edition, SPIE Press, 2012.
3. W. R. Runyan and K. E. Bean, Semiconductor Integrated Circuit Processing Technology, Addison Wesley Publishing Company, 1990
4. S. A. Campbell, The Science and Engineering of Microelectronic Fabrication, Oxford University Press, 1996.
5. M. J. Madou, Fundamentals of Micro fabrication, 2nd Edition, CRC Press, 2011.
6. S. M. Sze, Semiconductor Devices: Physics and Technology, 2nd Ed., Wiley India, 2011

List of Open-Source Software/ Learning website:

1. https://nptel.ac.in/courses/108106181
2. https://nptel.ac.in/courses/117102061
3. https://www.hitachi-hightech.com/global/products/device/semiconductor/process.html
4. https://nptel.ac.in/courses/108108112
5. https://www.semiconductors.org/turning-the-tide-for-semiconductor-manufacturing-in-the-u-s/

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO2	2	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO3	2	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO4	-	2	2	2	2	-	-	-	-	-	-	-	-	2	-
CO5	-	-	2	2	2	-	-	-	-	-	-	-	-	2	-
Avg.	2	2	2	2	2	-	-	-	-	-	-	-	-	2	-

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23041 **MICRO ELECTRO-MECHANICAL SYSTEMS**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION **9L**

Intrinsic Characteristics of Micro systems – Macro and micro-Sensors and Actuators –Scaling laws - Silicon and polymer-based MEMS processes and MEMS Materials

UNIT – II MICROMACHINING 9L

Bulk Micromachining - Surface micromachining, LIGA processes and Polymer MEMS fabrication process.

UNIT – III SENSORS AND ACTUATORS - I 9L

Electrostatic sensors – Parallel plate capacitors – Applications – Micro motors – Inter digitated Finger capacitor – Comb drive devices – Thermal Sensing and Actuation – Thermal expansion– Thermal couples – Thermal resistors – Applications – Microfluidics for sensing and actuation applications.

UNIT – IV SENSORS AND ACTUATORS - II 9L

Piezo resistive sensors – Piezo resistive sensor materials - Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and Flow sensors, Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials.

UNIT – V APPLICATIONS 9L

Application to Acceleration, Pressure, Flow, Chemical, Inertial sensors - Optical MEMS – Bio MEMS – RF MEMS – Energy Harvesting

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Select the proper materials for MEMS application. (L2)
2. Explain and compare the various techniques for micromachining and micro fabrication. (L2, L3)
3. Apply the concepts of MEMS to design the sensors and actuators. (L4)
4. Identify the right MEMS device against the applications. (L3)
5. Describe the fundamental working principles of different micro sensors and actuators. (L1)
6. Design MEMS devices for given applications. (L5)

REFERENCES:

1. Tai Ran Hsu, “MEMS and Micro systems Design and Manufacture” Tata McGraw Hill, New Delhi, 2006.
2. Stephen D Senturia, “Micro system Design”, Springer International Edition, 2006.
3. Gregory T. Kovacs “Micro machined Transducers Source Book”, McGraw-Hill High Education, 1998.
4. M.H.Bao, “Micromechanical Transducers: Pressure sensors, Accelerometers and Gyroscopes”, Elsevier, Newyork, 2000.
5. Tai Ran Hsu, "MEMS & Micro Systems Design, Manufacture and Nanoscale Engineering", John Wiley, New Jersy, 2008.
6. Chang Liu, "Foundations of MEMS", Pearson Education, 2012.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	-	-	-	-	-	1	-	1	-	-	-	-	-
CO2	-	-	-	-	3	-	-	1	3	1	-	3	-	-	-
CO3	-	-	3		3	-	-	1	3	1	-	3	-	2	-
CO4	-	-	-	-		-	3	1	-	1	-	-	-	-	-
CO5	-	-	-	-	3	-	-	1	3	1	-	3	-	-	-
CO6	-	2	-	-	-	-	-	1	-	1	-	3	3	-	-
Avg.	3	2.5	3	-	3	-	3	1	3	1	-	3	3	2	-

1 - low, 2-medium, 3-high, '-"- no correlation

EI23042 **NANO ELECTRONICS**

	L	T	P	C
	3	0	0	3

UNIT – I INTRODUCTION TO QUANTUM MECHANICS 9L

Particles, waves, probability amplitudes, Schrödinger equation, wave packets solutions, operators, expectation values, Eigen functions, piecewise constant potentials.

UNIT – II SIMPLE HARMONIC OSCILLATORS AND APPROXIMATIONS 9L

SHM Operators, SHM wave packet solutions, Quantum LC circuit, WKB approximations, variational methods.

UNIT – III SYSTEMS WITH TWO AND MANY DEGREES OF FREEDOM 9L

Two level systems with static and dynamic coupling, problems in more than one dimensions, electromagnetic field quantization, density of states.

UNIT – IV STATISTICAL MECHANICS 9L

Basic concepts, microscopic, quantum systems in equilibrium, statistical models applied to metals and semiconductors.

UNIT – V APPLICATIONS 9L

Hydrogen and Helium atoms, electronic states, Atomic force microscope, Nuclear Magnetic Resonance, carbon nanotube properties and applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain the fundamental science and quantum mechanics behind nanoelectronics. (L1, L2)
2. Apply eigenfunctions and probability densities for nanoelectronics. (L3)
3. Describe the statistical mechanics for understanding nanosystems. (L2)
4. Compare the systems with two and many degrees of freedom. (L4)
5. Infer the impact of nanoelectronics onto information technology, communication and computer science. (L4)
6. Summarise the applications of nanoelectronics. (L2)

REFERENCES:

1. Hagelstein, Peter L., Stephen D. Senturia, and Terry P. Orlando, "Introduction to Applied Quantum and Statistical Physics", New York, NY: Wiley, 2004.
2. Rainer Waser, "Nanoelectronics and Information Technology", Wiley, 3rd Edition, 2012
3. Michael A. Nielsen and Isaac L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 2000.
4. Neil Gershenfeld, "The Physics of Information Technology", Cambridge University Press, 2000.
5. Adrian Ionesu and Kaustav Banerjee eds. "Emerging Nanoelectronics Life with and after CMOS", , Vol I, II, and III, Kluwer Academic, 2005
6. Ismail, R., Ahmadi, M. T., & Anwar, S. (Eds.). (2018). Advanced nanoelectronics. CRC Press.
7. Tan, S. G., & Jalil, M. B. (Eds.). (2012). Introduction to the Physics of Nanoelectronics. Elsevier.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	-	-	-	-	-	1	-	1	-	-	-	-	-
CO2	-	-	-	-	3	-	-	1	3	1	-	3	-	-	-
CO3	-	-	3		3	-	-	1	3	1	-	3	-	2	-
CO4	-	-	-	-		-	3	1	-	1	-	-	-	-	-
CO5	-	-	-	-	3	-	-	1	3	1	-	3	-	-	-
CO6	-	2	-	-	-	-	-	1	-	1	-	3	3	-	-
Avg.	3	2.5	3	-	3	-	3	1	3	1	-	3	3	2	-

1 - low, 2-medium, 3-high, '-"- no correlation

EI23043 **GREEN ELECTRONICS**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION TO GREEN ELECTRONICS 9L

Environmental concerns of the modern society- Overview of electronics industry and their relevant regulations in China, European Union and other key countries- global and regional strategy and policy on green electronics industry. Restriction of Hazardous substances (RoHS) - Waste Electrical and electronic equipment (WEEE - Energy using Product (EuP) and Registration - Evaluation, Authorization and Restriction of Chemical substances (REACH).

UNIT – II GREEN ELECTRONICS MATERIALS AND PRODUCTS 9L

Basics of IC manufacturing and its process – Electronics with Lead (Pb) -free solder pastes, conductive adhesives, Introduction to green electronic materials and products - halogen-free substrates and components. Substitution of non-recyclable thermosetting polymer-based composites with recyclable materials X-Ray Fluorescence (XRF) for identifying hazardous substances in electronic products.

UNIT – III GREEN ELECTRONICS ASSEMBLY AND RECYCLING 9L

Various processes in assembling electronics components - the life-cycle environmental impacts of the materials used in the processes - substrate interconnects. Components and process equipments used. Technology and management on e-waste recycle system construction, global collaboration, and product disassembles technology.

UNIT – IV FLIP-CHIP ASSEMBLY AND BONDING FOR LEAD-FREE ELECTRONICS 9L

Flip-Chip Assembly Process – Placement and Under fill stage-FEM of Die stress – Gold stud Bump Bonding – Materials and Process Variations – Integrating Flip Chip into a Standard SMT Lead-Free Reflow soldering Techniques and Analytical Methods – Electro migration Analysis for Mean-Time-to-Failure Calculations – Gold-Tin Solder Integrating Vertical-Cavity Surface Emitting Lasers onto Integrated Circuits – Design and Processing of Flip-Chip Bonding Structures – Opto-Electronic Integration.

UNIT – V CASE STUDIES 9L

Lead-Free Electronic Design – Selection of the Package Type – Substrate or Die Attachment FR4 – Electrical Connections from Die to FR4 – Assess Impact of CTE Mismatch on Stress and Fatigue Life – Design Solder Balls for External Connection to PCB – Thermal Analysis of Flip-Chip Packaging – RLC for Flip-Chip Packages – Drop Test of Flip-Chip Packaging – Wei bull Distribution for Life Testing and Analysis of Test Data.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Interpretation of Data Sheet of electronics with respect to their Static and Dynamic Characteristics.
2. Selection of green electronics for product design.
3. Familiarization of any one relevant software tool (MATLAB/ SCILAB/ LABVIEW/ Proteus/ Equivalent open-source software)
4. Design and verification of simple signal conditioning circuit thro simulation.

5. Realization of signal conditioning circuit in hardware
6. Introduction to other advanced green electronics not covered in the above syllabus

COURSE OUTCOMES:

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

1. Relate theories, eco-design concepts and methods of green electronics (L1)
2. Explain the various materials used in green electronic products (L2)
3. Apply technology related to e-waste recycle system (L3)
4. Analyze eco-design processes involved in electronic industry. (L4)
5. Build environment friendly electronic manufacturing systems. (L3)

REFERENCES:

1. John X.Wang 'Green Electronics Manufacturing', CRC Press Indian Prentice Hall, 2012.
2. Sammy G. Shina, "Green Electronics Design and Manufacturing", McGraw Hill, 2008.c
3. Lee Goldberg, "Green Electronics/Green Bottom Line, Newnes Publications 2000
4. Green Communications and Networks, by Yuhang yang and Maode Ma, Springer Publication.

List of Open-Source Software/ Learning website:

1. http://tid.uio.no/kurs/fys4260/4260-Green_electronics.pdf
2. https://web.stanford.edu/class/ee152/resources/Course_Notes_092416.pdf

MAPPING OF COs WITH POs AND PSOs

O's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	1	1	1	-	2	1	1	-	1	-	-	-	2	-
CO2	2	2	1	2	-	2	1	1	-	1	-	-	-	2	-
CO3	3	2	2	2	-	2	2	1	-	1	-	-	-	2	-
CO4	3	3	3	2	-	2	1	1	-	1	-	-	-	2	-
CO5	3	2	2	2	-	2	1	1	-	1	-	-	-	2	-
Avg.	2	1.7	1.5	1.5	-	2	1.2	1	-	1	-	-	-	2	-

1-low, 2-medium, 3-high, '-"- no correlation

EMERGING TECHNOLOGY COURSE

EI23E01	**APPLIED DATA ANALYTICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To introduce students the basic concepts of

- Linear Regression Analysis
- Linear Model Selection and Regularization
- Classification
- Introduction to Advanced learning algorithms
- instrumentation and Control Applications of Data Analytics.

UNIT – I DATA PREPROCESSING 9L

Data quality – Data preprocessing: - Data Cleaning: – Handling missing data and noisy data – Outlier removal - Data integration: - Redundancy and correlation analysis – Continuous and Categorical Variables – Data Reduction: - Dimensionality reduction (Linear Discriminant Analysis – Principal Components Analysis).

UNIT – II DATA AUGMENTATION AND VALIDATION 9L

Practical Consideration in the Model selection - Validation methods to assess model quality:-The validation set approach, Leave-One-Out Cross Validation, k-Fold Cross Validation – Bias-variance Trade-off for k-Fold Cross Validation - Precision and recall - ROC curves - Data augmentation - data generative models

UNIT – III ADVANCED LEARNING TECHNIQUES (INTRODUCTION) 9L

Deep learning: Convolutional Neural Network (CNN) and Long Short Term Memory (LSTM) – Graph Neural Network (GNN) - Active learning - Transfer Learning – Federated Learning – Reinforcement Learning – Large Language Model – Natural Language Processing – Online/Self learning - Case studies.

UNIT – IV ML FOR PRODUCTION (MLOPS) 9L

ML in production – ML Data Lifecycle in production – ML modeling pipelines in production – Deploying ML models in production.

UNIT – V EDGE AI 9L

Challenges in deploying on embedded hardware- network compression - symmetric and asymmetric quantization - dynamic quantization - quantization aware training - pruning - knowledge distillation - Neural architecture search

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Be able to select the right choice of regression method for a given application.
2. Be able to select the right choice of classification method for a given application.
3. Be able to carry out subset selection and dimensionality reduction with the given data.
4. Ability to choose appropriate advanced learning algorithm for a given application.
5. Ability to carry out data driven analysis and process modeling.
6. Be able to systematically develop soft sensor and fault diagnosis for diversified applications.

REFERENCES:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, “An Introduction to Statistical Learning with Applications in R”, Springer Texts in Statistics, 2013.
2. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, 2013
3. Thomas A. Runkler, “Data Analytics: Models and Algorithms for Intelligent Data Analysis”, Springer Vieweg, 2nd Edition, 2016.
4. Artificial Intelligence, Machine Learning, and Deep Learning, Oswald Campesato, Mercury Learning and Information, 2020
5. Ian Goodfellow, Yoshua Bengio and Aaron Courville, “Deep Learning”, MIT Press, 2017.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	3	3	3	1	-	-	1	-	-	2	2	-	2
CO2	3	3	2	2	3	1	-	-	2	-	-	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	-	-	3	3	1	3
CO4	3	2	1	2	3	-	1	1	1	1	-	3	3	3	3
CO5	2	3	-	1	3	2	-	1	1	-	-	-	2	3	3
CO6	2	3	3	3	3	-	-	-	-	-	-	3	2	1	3
Avg	3	2	3	3	3	1	-	-	1	-	-	2	2	-	2

1-Low, 2-Medium, 3-High, ‘-“- no correlation

EI23E02 **MACHINE LEARNING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To give an introduction on several fundamental concepts and methods for machine learning.
- To familiarize with some basic learning algorithms and techniques and their applications.
- To provide knowledge related to processing, analyzing and handling data sets.
- To illustrate the typical applications of various clustering based learning algorithms

UNIT – I INTRODUCTION TO MACHINE LEARNING 9L

Objectives of machine learning – Human learning/ Machine learning – Types of Machine learning: - Supervised Learning – Unsupervised learning – Regression – Classification – The Machine Learning Process:- Data Collection and Preparation – Feature Selection – Algorithm Choice – Parameter and Model Selection – Training – Evaluation – Bias-Variance Tradeoff – Under fitting and Over fitting Problems.

UNIT – II SUPERVISED LEARNING 9L

Linear regression – Kernel – Regularization - Logistic Regression – Radial Basis Function Network – Support Vector Machines - Kernels – Risk and Loss Functions - Support Vector Machine Algorithm – Multi Class Classification – Support Vector Regression - Recommender systems.

UNIT – III CLUSTERING AND UNSUPERVISED LEARNING 9L

Introduction – Clustering: - Partitioning Methods: - K-means algorithm – Mean Shift Clustering – Hierarchical clustering – Clustering using Gaussian Mixture Models – Fuzzy mean Clustering - Clustering High-Dimensional Data – Similarities – Problems – Challenges.

UNIT – IV NEURAL NETWORKS 9L

Neural Network fundamentals – Activation functions –Multi-Layer Perceptron – Backpropagation Learning Algorithm – Types of Loss Function – Optimization: Gradient Descent Algorithm – Stochastic Gradient Descent - Momentum - Adam – Skip connections - CNN - RNN - Case study of few CNN architectures (Alex net, Resnet)

UNIT – V RECENT TOPICS 9L

LSTM - Attention mechanism - Vision transformers - Reinforcement learning - Q learning with neural networks - Actor Critic - U-Net – GAN

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Explore the areas and applications where machine learning is used.
2. Collect data for any application and apply data preprocessing techniques.
3. Develop prediction model using the Machine learning techniques.
4. Design controller using Neural Network for any one application

COURSE OUTCOMES:

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

1. Ability to understand a range of machine learning algorithms along with their strengths and weaknesses
2. Ability to analyze the data and identify appropriate preprocessing methods for cleaning the data.
3. Ability to formulate machine learning problems corresponding to different applications.
4. Ability to apply machine learning algorithms to solve problems of moderate complexity.

5. Ability to read current research papers and understand the issues raised by current research.

REFERENCES:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer Texts in Statistics,2013.
2. Thomas A. Runkler, Data Analytics: Models and Algorithms for Intelligent Data Analysis, Springer Vieweg, 2nd Edition,2016.
3. EthemAlpaydin, —Introduction to Machine Learning (AdaptiveComputation andMachine Learning), The MIT Press 2004.
4. Stephen Marsland, —Machine Learning: An Algorithmic Perspective, CRC Press, 2009

List of Open Source Software/ Learning website:

1. https://lecturenotes.in/materials/64801-machine-learning-for-engineering-and-science-applications
2. https://nptel.ac.in/courses/106105152
3. https://nptel.ac.in/courses/106106139
4. https://nptel.ac.in/courses/106106202
5. https://nptel.ac.in/courses/110101145

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	-	-	-	3	-	-	-	3	-	-	-	-	-	2	-
CO2	-	2	-	3	-	2	-	3	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	3	-	-	-	-	-	2	-
CO4	-	2	-	3	-	2	-	-	-	-	-	-	-	2	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Avg	-	2	-	3	-	2	-	3	-	-	-	-	-	2	-

1-Low, 2-Medium, 3-High, '-"- no correlation

EI23E03 **RENEWABLE POWER GENERATION SYSTEMS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

-

UNIT – I RENEWABLE ENERGY (RE) SOURCES 9L

Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, disposal of nuclear waste – GHG emission from various energy sources and its effects.

UNIT – II WIND ENERGY 9L

Power in the Wind – Types of Wind Power Plants(WPPs)–Components of WPPs-Working of WPPs- Sitting of WPPs-Grid integration issues of WPPs.

UNIT – III SOLAR PV AND THERMAL SYSTEMS 9L

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds.- Thermal Energy storage system with PCM- Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array, Efficiency & Quality of the Cell, maximum power point tracking, Applications.

UNIT – IV BIOMASS ENERGY 9L

Introduction-Bio mass resources –Energy from Bio mass: conversion processes-Biomass Cogeneration-Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydro power: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system.

UNIT – V OTHER ENERGY SOURCES 9L

Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)- Hydrogen Production and Storage- Fuel cell : Principle of working- various types – construction and applications. Energy Storage System- Hybrid Energy Systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Apprise the environmental impacts of conventional energy sources and the need of renewable energy.
2. Explain the process of PV generation and design stand-alone and grid connected system.
3. Describe the process of wind power generation and choose stand-alone and grid connected configuration.
4. Describe the basics of hydral, Geothermal and Biomass power generation.
5. Understands the working principle of fuel cell Describe the principle of tidal power generating systems

REFERENCES:

1. G D Rai, 'Non-conventional Energy sources', Khanna Publishers, 5th Edition, 2014.
2. D P Kothari, K C Singal and Rakesh Ranjan, 'Renewable Energy Sources and Emerging Technologies' 2nd Edition, 2012.
3. C S Solanki, 'Solar Photo-voltaics – Fundamentals, Technologies and Applications', PHI Pvt.,Ltd., 2nd Edition, 2011.

4. S N Bhadra, D Kastha and S Banerjee, 'Wind Electric Systems', Oxford Publications, 2nd Edition,2007.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's											PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	-	-	-	3	3	3	-	-	-	-	-	3	-	-
CO2	3	-	3	-	3	3	3	-	-	-	-	-	3	-	-
CO3	3	-	3	-	3	3	3	-	-	-	-	-	3	-	-
CO4	3	3	-	-	3	3	3	-	-	-	-	-	3	-	-
CO5	3	3	-	-	3	3	3	-	-	-	-	-	3	-	-
Avg.	3	3	3	-	3	3	3	-	-	-	-	-	3	-	-

1-low, 2-medium, 3-high, '-"- no correlation

OPEN ELECTIVE COURSE

		L	T	P	C
EI23901	**INTRODUCTION TO INDUSTRIAL INSTRUMENTATION AND CONTROL**	**3**	**0**	**0**	**3**

UNIT – I LEVEL AND PRESSURE MEASUREMENT 9L

Level Measurements: Float gauge – Displacer – D/P method – Load cell – Capacitive sensor– Ultrasonic sensor. Pressure Measurements: Manometer – Bourdon tube – Capacitive type pressure gauge – Piezo resistive pressure sensor – McLeod gauge – Thermal conductivity gauge.

UNIT – II TEMPERATURE MEASUREMENT 9L

Thermometers – RTD characteristics and signal conditioning – Thermistors – Thermocouples: Laws – signal conditioning – cold junction compensation. Radiation and optical pyrometers.

UNIT – III FLOW MEASUREMENT 9L

Orifice plate – venturi tube – Turbine flow meter – Rotameter – Coriolis mass flow meter – Thermal mass flow meter - Electromagnetic flow meter – Ultrasonic flow meter – Introduction to Calibrationmethods

UNIT – IV PROCESS CONTROL 9L

Need for process control – Continuous and Batch processes – servo and regulatory operations – Control valve - Examples: Level process – Flow process - Heat Exchanger. Controller: ON/OFF – PID controller – Electronic PID controller – Introduction to controller tuning.

UNIT – V ADVANCED CONTROL SCHEMES 9L

Ratio Control – Feed forward control - Cascade control – Model predictive control – Examples from boiler systems and distillation column.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Apply the knowledge about the instruments to use them more effectively
2. Ability to select appropriate level and pressure measuring instruments according tothe application
3. Ability to design signal conditioning circuits and compensation schemes
4. Able to understand the different conventional control actions, their relative merits,demerits and their typical applications
5. Able to analyze the need for advanced control and methods of implementation of these control techniques.
6. Ability to design & implement a suitable control scheme for a given process.

REFERENCES:

1. Doebelin. E.O and Manik D.N.," Measurement Systems: Application and Design", SpecialEdition, Tata McGraw Hill Education Pvt. Ltd, 2007
2. Bequette. B. W.," Process Control Modeling, Design and Simulation", Prentice Hall of India,2004

3. Liptak B.G., “Instrument and Automation Engineers’ Handbook: Process Measurement and Analysis”, Fifth Edition, CRC Press, 2016.
4. Patranabis. D., “Principles of Industrial Instrumentation”, 3rd Edition, Tata McGraw Hill, NewDelhi, 2010.
5. Stephanopoulos, “Chemical Process Control – An Introduction to Theory and Practice”, Prentice Hall of India, 2005

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	2	-	-	-	-	-	2	-	-	2	-	-
CO3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	2	-	-	2	-	-	2	-	-	2	-	-
CO5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	2	-	-	-	-	-	2	-	-	2	-	-
Avg.	2	-	-	2	-	-	2	-	-	2	-	-	2	-	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23902 INTRODUCTION TO INDUSTRIAL DATA COMMUNICATION

L	T	P	C
3	0	0	3

UNIT – I DATA NETWORK BASICS 9L

Introduction to Data network – OSI Network model – LAN topologies – Ethernet Protocol – Overview of protocols and standards used in Industrial Data Networks.

UNIT – II SERIAL COMMUNICATION STANDARDS 9L

Introduction to Serial Communication Standards: EIA232, EIA485, I2C and USB – Features, Elements, Connections and Handshaking.

UNIT – III FUNDAMENTALS OF MODBUS AND CANBUS 9L

MODBUS:- Overview, Protocol structure, Communication, Request and Response messages and Applications. CANBUS:- Standard and Extended CAN, Message types, Architecture, Data Transmission and Applications

UNIT – IV INTRODUCTION TO FIELDBUS AND HART 9L

Fieldbus:- Introduction, Protocol stack, Packet format, types and Applications – HART:-Features, modes, instruction formats and Applications.

UNIT – V WIRELESS NETWORKS FOR INDUSTRIAL DATA COMMUNICATION 9L

Wired Vs Wireless Communication – Challenges in Wireless Communication - Wireless LAN Protocol fundamentals, Introduction to Wireless HART Protocol.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Acquire knowledge about basic concepts of data networks
2. Gain familiarity with various serial interface standards used in industrial data networks.
3. Gain knowledge on the principles of MODBUS and CANBUS protocols.
4. Get familiarized with Foundation Fieldbus and HART Protocols.
5. Gain familiarity with wireless networks for industrial data communication.
6. Apply the knowledge of various communication standards for different application and use them more effectively.

REFERENCES:

1. Mackay.S, Wrijut.E, Reynders.D and Park.J. “Practical Industrial Data Networks Design, Installation and Troubleshooting”, Newnes Publication, Elsevier, 1st Edition, 2004.
2. Berge.J., “Field Buses for Process Control: Engineering, Operation and Maintenance”,ISA Press, 2004.
3. Berhouz.A. Forouzan, “Data Communications and Networking”, 4th Edition, TataMcGraw Hill, 2007.
4. Buchanan.W., “Computer Buses”, CRC Press, 2000.
5. NPTEL Notes on “Fieldbus Networks” and “Computer Networks”, IIT Kharagpur.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	2	-	-	-	-	-	2	-	-	2	-	-
CO3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	2	-	-	2	-	-	2	-	-	2	-	-
CO5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	2	-	-	-	-	-	2	-	-	2	-	-
Avg.	2	-	-	2	-	-	2	-	-	2	-	-	2	-	-

1 - low, 2-medium, 3-high, '-"- no correlation

EI23903 **INDUSTRIAL AUTOMATION SYSTEMS**

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION 9L

Need for automation systems - Architecture of Industrial Automation system. Introduction to PLC, SCADA and DCS – Introduction to Industrial Data Networks:- Foundation Field Bus and Profibus.

UNIT – II FIELD DEVICES 9L

Conventional / Smart Process Transmitters:- Temperature, Pressure, Flow, Level and pH Measurement - Final Control Elements:- Actuators: Pneumatic and electric actuators - Control Valves - Thyrister Power Controller. Introduction to DC and AC Servo Drives for motion control – Interfacing Field devices with I/O Sub Systems.

UNIT – III COMPUTER AIDED MEASUREMENT AND CONTROL SYSTEMS 9L

Role of computers in measurement and control - Elements of computer aided measurement and control:- Man-Machine interface, computer aided process control hardware and software – Industrial Internet of things (I2oT) – Cyber Security for Industrial automation

UNIT – IV PROGRAMMABLE LOGIC CONTROLLERS 9L

Programmable Logic Controllers:- Hardware of PLC - PLC programming:-Ladder diagram with examples - PLC Communication and networking - Case studies:- Bottle filling application and Elevator control.

UNIT – V DISTRIBUTED CONTROL SYSTEM 9L

DCS:- LCU-Shared communication facility- Display Hierarchy- High Level and Low Level interfaces - Case studies:- DCS in cement plant and thermal power plant.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Gain knowledge on basics of Industrial Automation
2. Ability to select appropriate Transmitters, Final control elements and Controllers for different application
3. Gain familiarity with Computer aided measurement and control
4. Students will be able to Develop Ladder programmes for PLC
5. Acquire knowledge about Distributed Control System
6. Will be able to recommend right choice of automation systems for a given application

REFERENCES:

1. S.K.Singh, “Industrial Instrumentation”, Tata Mcgraw Hill, 2nd edition companies,2003.
2. C D Johnson, “Process Control Instrumentation Technology”, Prentice Hall India, 8thEdition, 2006.
3. E.A.Parr, Newnes , NewDelhi, “Industrial Control Handbook”, 3rd Edition, 2000.
4. Gary Dunning, Thomson Delmar, “Programmable Logic Controller”, Ceneage Learning, 3rdEdition,2005.
5. Lucas, M.P., “Distributed Control System”, Van Nostrand Reinhold Company,New York,1986.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	2	3	-	-	-	-	2	-	-	2	-	-
CO3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	2	-	-	2	-	-	2	-	-	2	-	-
CO5	2	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	2	-	-	-	-	-	2	-	-	2	-	-
Avg.	2	-	-	2	3	-	2	-	-	2	-	-	2	-	-

1 - low, 2-medium, 3-high, '-"- no correlation

EI23904 INTRODUCTION TO PROGRAMMABLE LOGIC CONTROLLER

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION 9L

Introduction to Hardwired Relay Logic and Solid-state Logic - Examples – Introduction to Programmable Logic - Examples - Role of PLC in an Industrial automation.

UNIT – II PLC ARCHITECTURE 9L

Architecture of PLC - Input/output modules:- Analog/Digital Input/output modules - Scan cycle of PLC. Introduction to PLC Programming languages:- Ladder Diagram(LD), Function Block Diagram(FBD), Sequential Function Charts(SFC), Instruction List(IL), Structured Text(ST).

UNIT – III IEC 61131-3 PLC PROGRAMMING STANDARD 9L

IEC 61131-3 Standard Building Blocks of IEC 61131-3 - Elements of Program Organization Unit: Variables, Data types and Common elements - Standard Functions.

UNIT – IV PLC PROGRAMMING 9L

Ladder Logic Programming: - Relay Logic Instructions, Timer, Counter, Math and Program Control instructions - Function Block Diagram – Examples.

UNIT – V CASE STUDIES 9L

Case studies: Burner Management System in a Thermal Power Plant - Traffic Light Control System - Bottle filling application - Elevator Control – Robotic Arm Control.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Ability to understand the role of PLC in the Factory Automation and Process Automation
2. Get exposed to different ways of Programming PLC.
3. Get exposed to IEC 61131-3 standard
4. Ability to develop Ladder Diagram and Functional Block Diagram for typical Industrial applications.
5. Ability to apply various logic instruction for different application
6. Apply the knowledge of PLC for various application

REFERENCES:

1. Petruzella.F.D. “Programmable Logic Controllers”, 3rd Edition, Tata McGraw-Hill, 2010.
2. Hughes.T.A. “Programmable Logic Controllers: Resources for Measurements and Control Series”, 3rd Edition, ISA Press, 2004.
3. Karl-Heinz John, Michael Tiegelkamp, “IEC 61131–3: Programming Industrial Automation Systems”, 2001.
4. Gary Dunning and Thomson Delmar, “Programmable Logic Controller”, 3rd Edition, Ceneage Learning, 2005

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	2	-	-	-	-	-	2	-	-	2	-	-
CO3	1	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	2	-	-	2	-	2	2	-	-	2	-	-
CO5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	2	-	-	2	3	-	-	-	2	2	-	-	2	-	-
Avg.	2	-	-	2	3	-	2	-	2	2	-	-	2	-	-

1 - low, 2-medium, 3-high, '-"- no correlation

MINOR ELECTIVES

EI23044 **TRANSDUCER ENGINEERING**

L	T	P	C
3	0	0	3

UNIT – I SCIENCE OF MEASUREMENT AND TRANSDUCTION 9L

Units and standards – Calibration methods – Classification of errors - Error analysis –Limiting error - Probable error - Propagation of errors- Odds and uncertainty- Principle of transduction - Classification.

UNIT – II CHARACTERISTICS OF TRANSDUCERS 9L

Static characteristics – Accuracy – Precision – Sensitivity - Linearity etc. – Mathematical model of transducers – Zero – First order and second order transducers – Response to impulse-Step - Ramp and sinusoidal inputs.

UNIT – III VARIABLE RESISTANCE TRANSDUCERS 9L

Principle of operation - Construction details - Characteristics and applications of resistance potentiometers - Strain gauges - Resistance thermometers – Thermistors - Hotwire anemometer - Piezoresistive sensors and humidity sensors.

UNIT – IV VARIABLE INDUCTANCE AND VARIABLE CAPACITANCE TRANSDUCERS 9L

Induction potentiometer – Variable reluctance transducers – EI pick up – LVDT – Capacitive transducers – Variable air gap type – Variable area type – Variable permittivity type – Capacitor microphone.

UNIT – V OTHER TRANSDUCERS 9L

Piezoelectric transducer – Magnetostrictive transducer – IC sensor – Digital transducers – Smart sensor – Fiber optic transducers - Hall effect transducers - Feedback transducers - Introduction to MEMS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Understand the role of standards organization
2. Ability to implement different standards related to installation and control system, programming, documentation, equipments in hazardous area and instrument specification forms.
3. Skill to utilise standards related to control valve, actuators. orifice sizing, RTD and thermocouple
4. Capability to implement standards related to power plant and nuclear power plant.
5. Ability to select different standards related to orifice, RTD and thermocouple.
   Select standards related to programming language.

REFERENCES:

1. Doeblin E.O, Measurement Systems, McGraw-Hill Book Co., 1998.
2. Renganathan .S, Transducer Engineering, Allied Publishers, Chennai, 1999.

3. John P.Bentley,'Principles of Measurement Systems',Third edition,Addison Wesley Longman Ltd.,UK,2000.
4. Patranabis, D, Sensors and Transducers, Wheeler Publishing Co., Ltd. New Delhi, 1997.
5. Murthy, D.V.S., Transducers and Instrumentation, Prentice Hall of India Pvt. Ltd., New Delhi, 1995.
6. Neubert H.K.P, Instrument Transducers, Clarenden Press, Oxford, 1988.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
CO2	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
CO4	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
CO5	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
CO6	-	-	-	1	-	1	-	-	-	-	-	-	-	-	1
Avg.	-	-	-	1	1	1	-	-	-	-	-	-	1	-	1

1 - low, 2-medium, 3-high, '-"- no correlation

EI23044 **TRANSDUCER ENGINEERING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

-

UNIT – I MEASUREMENT TEMPERATURE 9L

Definitions and standards – Resistance Temperature Detectors –Thermocouple- Radiation thermometers – Fiber optic temperature sensor– Temperature sensor selection, Installation and Calibration..

UNIT – II MEASUREMENT OF PRESSURE 9L

Units of pressure – Manometers- Elastic type pressure gauges - Electrical pressure transducers- Fiber optic pressure sensor Measurement of vacuum: McLeod gauge, Cold cathode type and hot cathode type ionization gauges – Pressure gauge selection, installation and calibration.

UNIT – III MEASUREMENT OF FLOW 9L

Variable head flow meters – positive displacement flow meters-variable area flow meters- Electrical type flow meters – Open channel flow measurement –Solid flow measurement.

UNIT – IV MEASUREMENT OF LEVEL 9L

Float gauges – Displacer type – Bubbler system – Load cell – Conductivity sensors – Capacitive sensors – D/P methods – Ultrasonic level sensors –Solid level measurement.

UNIT – V INSTRUMENTS FOR CHEMICAL ANALYSIS 9L

Ion selective electrodes – pH and Conductivity measurement – UV Visible and IR Spectrometry- Gas & Liquid Chromatography – Mass Spectrometry- Oxygen analyzers for gas and liquid – CO,CO2 ,NO and SO Analyzers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain the construction, working and calibration of temperature, pressure, flow and level sensors. (L1, L2)
2. Appraise different chemical analyzers. (L5)
3. Select instruments for specific application. (L3)
4. Apply appropriate safety instrumented system and instrumentation standards in the industry. (L3)
5. Analyze process hazards and apply risk assessment techniques for an industrial plant. (L4)
6. Design, develop, and interpret the documents used to define instruments and control systems for a typical project, including P&IDs, loop diagrams, instrument lists, logic diagrams, installation details, and location plans. (L6)

REFERENCES:

1. Doebelin, E.O. and Manik D.N., “Measurement systems Application and Design”, 5th Edition, Tata McGraw-Hill Education Pvt. Ltd, 2009.
2. Braun, R.D., “Introduction to Instrumental Analysis”, Pharma Book Syndicate, Singapore, 7th Edition 2012
3. Paul Gruhn, P.E., CFSE and Harry Cheddie, P.E., “Safety Instrumented Systems: Design, Analysis, and Justification”, 2nd Edition, ISA,2006.

4. Safety - ANSI/ISA84.00.01-2004, Part 1: Framework, Definitions, System Hardware and Software Requirements; ANSI/ISA84.00.01-2004, Part 2: Functional Safety: Safety Instrumented Systems for the Process Industry Sector; ANSI/ISA84.00.01-2004, Part 3: Guidance for the Determination of the Required Safety Integrity Levels-Informative
5. B.G.Liptak, "Instrumentation Engineers Handbook (Process Measurement & Analysis)", Fourth Edition, Chilton Book Co, CRC Press, 2005. 4 Safety - ANSI/ISA84.00.01-2004, Part 1: Framework, Definitions, System Hardware and Software Requirements; ANSI/ISA84.00.01-2004 Part 2: Functional Safety: Safety Instrumented Systems for the Process Industry Sector; ANSI/ISA84.00.01-2004 Part 3: Guidance for the Determination of the Required Safety Integrity LevelsInformative6 Documentation Standards - ANSI/ISA5.4-1991 - Instrument Loop Diagrams; ANSI/ISA5.06.01-2007 - Functional Requirements Documentation for Control Software Applications; ANSI/ISA20-1981 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
6. Standards - ANSI/ISA-75.01.01 -2002 (60534-2-1 Mod): Flow Equations for Sizing control Valves; ISA84 Process Safety Standards and User Resources, Second Edition, ISA, 2011; ISA88 Batch Standards and User Resources, 4th Edition, ISA, 2011.
7. Documentation Standards - ANSI/ISA5.4-1991 - Instrument Loop Diagrams; ANSI/ISA5.06.01-2007 - Functional Requirements Documentation for Control Software Applications; ANSI/ISA20-1981 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	-	-	-	1	1	-	-	-	-	3	-	-
CO2	3	1	1	-	-	-	1	1	-	-	-	-	3	-	-
CO3	3	2	-	-	-	-	1	1	-	-	-	-	3	-	-
CO4	3	2	-	-	-	3	2	2	-	-	-	1	3	2	-
CO5	3	3	2	3	3	3	2	2	-	-	-	1	3	2	-
CO6	3	3	3	3	2	1	1	-	-	-	-	-	3	3	-
Avg.	3	2.2	1.8	3	2.5	2.3	1.3	1.4	-	-	-	1	3	2.3	-

1-low, 2-medium, 3-high, '-" - no correlation

EI23046 **INTRODUCTION TO PROCESS CONTROL**

L	T	P	C
3	0	0	3

UNIT – I PROCESS DYNAMICS 9L

Need for process control – Hierarchical decomposition of control functions – Servo and regulatory operations – Continuous and Batch processes – Mathematical Modeling of Processes: Level, Flow and Thermal processes – Lumped and Distributed parameter models – Degrees of Freedom – Interacting and non-interacting systems – Self regulation – Linearization of nonlinear systems – Dynamic behavior of processes

UNIT – II CONTROL VALVE 9L

Actuators: Pneumatic and electric actuators – I/P converter – Control Valve Terminology - Characteristic of Control Valves: Inherent and Installed characteristics - Valve Positioner – Modeling of a Pneumatically Actuated Control Valve – Valve body: Commercial valve bodies – Control Valve Sizing: ISA S 75.01 standard flow equations for sizing Control Valves – Cavitation and flashing – Materials for Control Valves – Control Valve selection.

UNIT – III CONTROL ACTIONS 9L

Characteristic of ON-OFF, Proportional, Single speed floating, Integral and Derivative controllers – P+I, P+D and P+I+D control modes – Practical forms of PID Controller – PID Implementation Issues: Bumpless Auto/manual Mode transfer, Anti-reset windup Techniques and Direct/reverse action – Realization of PID Controller using Analog Circuits – Introduction to fractional order PID controller.

UNIT – IV PID CONTROLLER TUNING – SINGLE LOOP REGULATORY CONTROL & ENHANCEMENT TO SINGLE LOOP REGULATORY CONTROL 9L

PID Controller Design Specifications: Criteria based on Time Response and Criteria based Frequency Response - PID Controller Tuning: Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method, optimization methods, Auto tuning – Cascade control – Feed-forward control – Ratio control – Inferential control – Split-range – override control – Adaptive Control.

UNIT – V MODEL BASED CONTROL SCHEMES & INTRODUCTION TO MULTILOOPREGULATORY CONTROL & CASE – STUDIES 9L

Smith Predictor Control Scheme - Internal Model Controller – IMC PID controller – Single Loop Dynamic Matrix Control – Introduction to Multi-loop Control Schemes – Control Schemes for Distillation Column, CSTR, pH, and Heat Exchanger – Three-element Boiler drum level control – P&ID diagram.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Ability to understand technical terms associated with Process control domain.
2. Ability to develop models using first principles approach for processes such as level, flow, temperature and pressure as well as analyze models.

3. Ability to recommend the right type of control valve along with its characteristics for a given application.
4. Ability to size a control valve following the procedure outlined in the ISA S 75.01 standard.
5. Ability to design & implement a suitable control scheme for a given process and validate through simulations.
6. Ability to analyze various control schemes and recommend the right control strategy for a given application.
7. Ability to use appropriate software tools (Example: MATLAB/SCILAB) for analysis, design and implementation of Process Control System.

REFERENCES:

1. Seborg ,D.E., Mellichamp, D.P., Edgar, T.F., and Doyle,F.J., III, “Process Dynamics and Control”, John Wiley and Sons, 3rd Edition, 2010.
2. Bequette, “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, 2004
3. Michael King, “Process Control: A Practical Approach”, Wiley, 2010.
4. Baumann, H.D., “Control Valve Primer – A User’s Guide”, ISA, 2008.
5. Antonio Visioli, “Practical PID Control” Springer- Verlag London, 2006.
6. Aidan O'Dwyer, “Handbook of PI and PID Controller Tuning Rules”, Imperial College Press, 2009.
7. George Stephanopoulos, “Chemical Process Control – An Introduction to Theory and
8. Practice”, Prentice Hall of India, 2005.
   Bela G. Liptak, “Instrument Engineers' Handbook”, 4th Edition, Volume Two: Process Control and Optimization, CRC Press, 2005.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	2	2	2	1	-	1	-	2	-	3	-
CO2	3	3	3	3	2	-	2	1	-	1	2	-	-	3	-
CO3	3	3	3	3	2	2	-	1	-	1	-	-	-	3	-
CO4	3	3	3	3	2	2	-	1	-	1	-	-	-	3	-
CO5	3	3	3	3	3	2	-	1	-	1	-	2	-	3	-
CO6	3	3	3	3	3	2	-	1	-	1	-	2	-	3	-
CO7	3	3	3	3	3	2	-	1	-	1	-	2	-	3	-
Avg.	3	3	3	3	2.43	2	2	1	-	1	2	2	-	3	-

1 - low, 2-medium, 3-high, ‘-“- no correlation

EI23047 FUNDAMENTALS OF INDUSTRIAL DATA COMMUNICATION

L	T	P	C
3	0	0	3

UNIT – I DATA NETWORK FUNDAMENTALS 9L

EIA 232 interface standard – EIA 485 interface standard – ISO/OSI Reference model – Media access protocol: Command/response, Token passing and CSMA/CD – TCP/IP – Bridges – Routers – Gateways – Standard ETHERNET Configuration

UNIT – II MODBUS AND HART 9L

MODBUS: protocol structure, Function codes. Evolution of signal standard: HART communication protocol – Communication modes – HART Networks – HART commands – HART applications – Troubleshooting

UNIT – III PROFIBUS AND FF 9L

Fieldbus: Introduction – General Fieldbus architecture – Basic requirements of Fieldbus standard – Fieldbus topology – Interoperability and Interchangeability. Profibus: Introduction – Profibus protocol stack – Profibus communication model – Communication objects – Foundation field bus versus Profibus..

UNIT – IV AS – INTERFACE (AS-i), DEVICENET AND INDUSTRIAL ETHERNET 9L

AS interface: Introduction – Physical layer – Data link layer – Operating characteristics. Device net: Introduction – Physical layer – Data link layer and Application layer. Industrial Ethernet: Introduction – 10Mbps Ethernet – 100Mbps Ethernet.

UNIT – V WIRELESS COMMUNICATION 9L

Wireless sensor networks: Hardware components – energy consumption of sensor nodes – Network architecture – sensor network scenario. Wireless HART – Existing Wireless Options: IEEE 802.15.4 - ISA 100 – Zigbee – Bluetooth – their relevance to industrial applications

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Be able to gain knowledge on various Industrial data networking standards their evolution, associated hardware and software
2. Be able to analyse and select proper protocol for device level and control level integration
3. Be able to establish/design networking for process control applications and industrial automation
4. Be able to apply gained knowledge on networking to compare and choose a specific protocol for the given architecture.
5. Be able to infer the requirements of an industry and provide a wired or wireless solution for installing Industrial data network

REFERENCES:

1. Mackay, S., Wright,E., Reynders,D., and Park,J., “Practical Industrial Data Networks:Design, Installation and Troubleshooting”, Newnes Publication, Elsevier, 2004.
2. Buchanan,W., “Computer Busses: Design and Application”, CRC Press, 2000.
3. Bowden,R., “HART Application Guide”, HART Communication Foundation, 1999.

4. Bela G.Liptak, "Instrument Engineers' Handbook, Volume 3 : Process Software and DigitalNetworks", 4th Edition, CRC Press, 2011.
5. Berge,J., "Field Buses for Process Control: Engineering, Operation, and Maintenance", ISAPress, 2004
6. Lawrence (Larry) M. Thompson and Tim Shaw, "Industrial Data Communications", 5th Edition, ISA Press, 2015.
7. NPTEL Lecture notes on, "Computer Networks" by Department of Electrical Engg., IIT Kharagpur.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	2	-	-	1	1	1	1	3	1	-	2
CO2	3	3	3	3	2	1	-	1	1	2	1	3	1	-	2
CO3	3	3	2	2	3	1	-	1	1	2	1	3	1	-	3
CO4	3	3	3	3	3	1	-	1	1	2	1	3	1	-	2
CO5	3	3	3	3	3	1	-	1	1	2	1	3	1	-	2
Avg.	3	3	2.6	2.6	2.6	1	-	1	1	1.8	1	3	1	-	2.2

1 - low, 2-medium, 3-high, '-"- no correlation

EI23048 **ANALYTICAL INSTRUMENTATION SYSTEMS**

L	T	P	C
3	0	0	3

UNIT – I SPECTROPHOTOMETRY 9L

Spectral methods of analysis – Beer-Lambert law – UV-Visible spectroscopy – IR Spectrophotometry - FTIR spectrophotometry – Atomic absorption spectrophotometry - Flame emission and atomic emission photometry – Construction, working principle, sources detectors and applications.

UNIT – II CHROMATOGRAPHY 9L

General principles – classification – chromatographic behavior of solutes – quantitative determination – Gas chromatography – Liquid chromatography - High-pressure liquid chromatography – Applications.

UNIT – III INDUSTRIAL GAS ANALYZERS AND POLLUTION MONITORING INSTRUMENTS 9L

Gas analyzers – Oxygen, NO2 and H2S types, IR analyzers, thermal conductivity detectors, analysis based on ionization of gases. Air pollution due to carbon monoxide, hydrocarbons, nitrogen oxides, sulphur dioxide estimation - Dust and smoke measurements.

UNIT – IV pH METERS AND DISSOLVED COMPONENT ANALYZERS 9L

Selective ion electrodes - Principle of pH and conductivity measurement - dissolved oxygen analyzer – Sodium analyzer – Silicon analyzer – Water quality Analyzers.

UNIT – V NUCLEAR MAGNETIC RESONANCE AND MASS SPECTROMETRY 9L

NMR – Basic principles – Continuous and Pulsed Fourier Transform NMR spectrometer – Mass Spectrometry – Sample system – Ionization methods – Mass analyzers – Types of mass spectrometry.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Ability to understand the basic concept of qualitative and quantitative analysis of a given sample.
2. Ability to posess working knowledge of analytical instrumentation typically employed in chemical/biochemical research and industry laboratories
3. Ability to apply the fundamental principles of selective analytical instruments for separation, identification and quantitative analysis of chemical substances.
4. Describe and differentiate between online and offline process and identify suitable instruments for analysis.
5. Ability to appreciate the relative strengths and limitations of different instrumental based analysis methods.
6. Ability to assess and suggest a suitable analytical method for a specific application.

REFERENCES:

1. Braun, R.D., "Introduction to Instrumental Analysis", Pharma Book Syndicate, Singapore, 2nd edition 2012.. EI5001 ANALYTICAL INSTRUMENTATION L T P C 3 0 0 3 101
2. Willard, H.H., Merritt, L.L., Dean, J.A., Settle, F.A.," Instrumental methods of analysis", CBS publishing & distribution, 7th Edition, 2012.
3. Robert E. Sherman., "Analytical Instrumentation, Instruments", Society of America, 1996
4. Khandpur, R.S., "Handbook of Analytical Instruments", Tata McGraw Hill publishing Co. Ltd., 5th edition 2018.
5. Ewing, G.W., "Instrumental Methods of Chemical Analysis", McGraw Hill, 5th edition reprint 1985. Digitized in 2007.
6. Liptak, B.G., "Process Measurement and Analysis", CRC Press, 5th Edition, 2016.
   NPTEL lecture notes on, "Modern Instrumental methods of Analysis" by Dr.J.R. Mudakavi, IISC, Bangalore.

MAPPING OF COs WITH POs AND PSOs

CO's	PO's												PSO's		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	1	1	1	3	1	1	1	1	1	1	1	1	1	1
CO2	3	1	1	1	3	1	1	1	1	1	1	1	1	1	1
CO3	1	1	1	1	3	2	1	1	1	1	1	1	1	1	1
CO4	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1
CO5	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1
CO6	3	2	2	1	2	3	2	2	2	2	1	1	1	1	1
Avg.	2	1.8	1.2	2.6	1.6	1	1	1	1	1	1	1	1	1	1

1 - low, 2-medium, 3-high, '-"- no correlation

EI23049 LOGIC AND DISTRIBUTED CONTROL SYSTEM

L	T	P	C
3	0	0	3

UNIT – I INTRODUCTION TO PLC 9L

Definition of Automation - Types of Automation - Automation Strategies-Automation Hierarchy-Introduction of PLC and its architecture-Evolution of control technology – Fixed and Modular PLCs- modules and addressing -Local/Remote/Distributed I/O-Wiring of field devices to various modules-PLC selection criteria – SCADA – HMI.

PRACTICALS:

UNIT – II INTERFACING OF INPUT - OUTPUT DEVICES 9L

Recall of basic electrical components-Push Buttons, Limit switches, proximity sensor Photoelectric sensors, Infrared sensors, electromechanical, solenoid valves, control valves, positioners linear, rotary Contactors, Bi metal Relays, interfacing to PLC. Relays and contactors-Structure of a relay, Applications of relays- Star delta starter, soft starter, VFD -interfacing with PLC. Interfacing Servomotor with PLC with encoder feedback.

PRACTICALS:

UNIT – III PLC PROGRAMMING 9L

Basics of PLC programming – Ladder Logic – Timer/Counter instructions –Program control instructions – Data manipulation and math instructions – Programming Examples. Introduction to other IEC61131-3 programming techniques -Functional block programming - Sequential Function Chart – Instruction list – Structured text programming.

PRACTICALS:

UNIT – IV CONTROL PANEL AND ADVANCES IN AUTOMATION 9L

Control panel layout- components, terminals, Fuses, MCB, terminal blocks, wiring duct, DIN rail, terminating resistor, earth and interconnections. Reading Electrical wiring diagrams- Termination and jointing of cables, Working with Site Plans and Symbols, Prepare wiring layout, I/O list, wiring list and drawings. ESD, Fire alarms -Factory Acceptance Test. PAC-OPC UA – Safety PLC – Case studies: PLC Introduction to Networked Control systems – Plant wide control – Internet of things – Cloud based Automation-ML for predictive maintenance in automation.

PRACTICALS:

UNIT – V DISTRIBUTED CONTROL SYSTEM 9L

DCS: Evolution & types – Hardware architecture – Field control station – Interfacing of conventional and smart field devices (HART and FF enabled) with DCS Controller – Communication modules – Operator and Engineering Human interface stations – Study of any one DCS available in market.

PRACTICALS:

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Explain automation components and systems application. (L2)
2. Identify suitable industrial automation hardware for given application. (L1)

3. Impart the role of PLC in industry automation. (L3)
4. Select a suitable sensor and actuator for a given automation application and demonstrate its use in a specific application.(L4)
5. Analyse & control the pneumatic actuators using various pneumatic valves. (L4)
   Develop ladder diagrams for a given application and explain its implementation process using PLC.(L5)

REFERENCES:

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2. W. Bolton, "Programmable Logic Controllers ", 5th Edition, Newnes, 2009.
3. Hughes, T.A., “Programmable Logic Controllers: Resources for Measurements and Control Series”, 3rd Edition, ISA Press, 2004.
4. NPTEL Notes on, “Programmable Logic Control System” by Department of Electrical Engg., IIT Kharagpur.
5. F. Ebel, S. Idler, G. Prede, D. Scholz, "Fundamentals of automation technology Technical book”, Festo, 2008.
6. Stamatios Manesis and George Nikolakopoulos, “Introduction to Industrial Automation”, CRC Press, 2018.
7. Richerd L. Shell and Ernest L. Hall, “Hand Book of Industrial Automation”, CRC Press, 2000.

MAPPING OF COs WITH POs AND PSOs

CO’s	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	3	3	3	1	-	-	1	-	-	2	2	-	2
CO2	3	3	2	2	3	1	-	-	2	-	-	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	-	-	3	3	1	3
CO4	3	2	1	2	3	-	1	1	1	1	-	3	3	3	3
CO5	2	3	-	1	3	2	-	1	1	-	-	-	2	3	3
CO6	2	3	3	3	3	-	-	-	-	-	-	3	2	1	3
Avg.	2.7	2.7	2.4	2.3	3	1.25	1	1	1.2	1	-	2.6	2.3	2	2.8

1-Low, 2-Medium, 3-High, ‘-“- no correlation