ANNAMALAI UNIVERSITY
DEPARTMENT OF ELECTRONICS & INSTRUMENTATION ENGINEERING

VISION

To nurture higher echelons of technology through participative education, innovative and collaborative research with a view to bring out employable graduates of International standard.

MISSION

- To establish sate of art facilities related to diverse dimension in the field of Instrumentation Engineering, Biomedical Engineering and Microelectronics and MEMS.
- To foster higher quality of education with equivocal focus in theory and practical areas of Electronics, Control and Instrumentation Engineering, Biomedical Engineering and Microelectronics and MEMS.
- To ensure that the dissemination of knowledge reaches the stakeholders and forge the opening of a fresh flair of human resources.
- To create opportunities for advancements in different facets of this discipline and offer avenues to reach the citadels of one's carrier.

M.E. (PROCESS CONTROL AND INSTRUMENTATION)

PROGRAM EDUCATIONAL OBJECTIVES

The major objectives of the M.E (Process Control & Instrumentation) programme are to equip the students with adequate knowledge and skills in the areas of Process Control and Instrumentation and prepare them for:

1. Imparting practical knowledge in process control and design of instrumentation systems and contribute to technological development.
2. Attaining professional competency to address the technological needs of society and industrial problems.
3. A successful career in Process Control and Automation industries, R&D organizations and Academic Institutions.

PROGRAM OUTCOMES

A student who has undergone the M.E (Process Control & Instrumentation) program would have acquired abilities to

1. Apply knowledge of mathematics, science and engineering in practice.
2. Identify, analyse, formulate and solve engineering problems with comprehensive knowledge.
3. Handle emerging technologies relating to process industries.
4. Design process systems and provide solutions considering health, safety and environmental factors.
5. Provide innovative solutions to Industrial/Research problems.

Mapping of PEO with PO					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
PEO1	✓	✓	✓		✓
PEO2			✓		✓
PEO3		✓		✓	

ANNAMALAI UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY
M.E. / M. Tech (Two-Year Full Time& Three-year Part Time) DEGREE PROGRAMME

CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

1. Condition for Admission

Candidates for admission to the first year of the four-semester **M.E / M.Tech Degree programme in Engineering** shall be required to have passed B.E / B.Techdegree of Annamalai University or any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the condition regarding qualifying marks and physical fitness as may be prescribed by the syndicate of the AnnamalaiUniversity from time to time. The admission for part time programme is restricted to those working or residing within a radius of **90 km** from Annamalainagar. The application should be sent through their employers.

2. Branches of Study in M.E / M.Tech

The Branch and Eligibility criteria of programmes are given in **Annexure 1**

3. Courses of study

The courses of study and the respective syllabi for each of the M.E / M. Tech programmes offered by the different Departments of study are given separately.

4. Scheme of Examinations

The scheme of Examinations is given separately.

5. Choice Based Credit System (CBCS)

The curriculum includes three components namely Professional Core, Professional Electives and Open Electives in addition toThesis. Each semester curriculum shall normally have a blend of theory and practical courses.

6. Assignment of Credits for Courses

Each course is normally assigned one credit per hour of lecture / tutorial per week and one credit for two hours or part thereof for laboratory or practical per week.The total credits for the programme will be 65.

7. Duration of the programme

A student of **M.E / M.Tech**programme is normally expected to complete in four semesters for full-time / six semesters for part-time but in any case not more than four years for full-time / six years for part-time from the date of admission.

8. Registration for courses

A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day. Registration for the Thesis Phase - I and II shall be done at the appropriate semesters.

9. Electives

The student has to select two electives in first semester and another two electives in the second semester from the list of Professional Electives. The student has to select two electives in third semester from the list of Open Electives offered by the department/ allied department. A student may be allowed to take up the open elective courses of third semester (Full Time program) in the first and second semester, one course in each of the semesters to enable them to carry out thesis in an industry during the entire second year of study provided they should register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselvesfor clarifications. No specific slots will be allotted in the time table for such courses.

Further, the two open elective courses to be studied in III semester (Full Time programme) may also be credited through the SWAYAM portal of UGC with the approval of Head of the Department concerned. In such a case, the courses must be credited before the end of III Semester.

10. Assessment

The break-up of continuous assessment and examination marks for theory courses is as follows:

First assessment (Mid-Semester Test-I)	:	10 marks
Second assessment (Mid-Semester Test-II)	:	10 marks
Third Assessment	:	5 marks
End Semester Examination	:	75 marks

The break-up of continuous assessment and examination marks for Practical courses is as follows:

First assessment (Test-I)	:	15 marks
Second assessment (Test-II)	:	15 marks
Maintenance of record book	:	10 marks
End Semester Examination	:	60 marks

The thesis Phase I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. The number of reviews must be a minimum of three per semester. 60 marks are allotted for the thesis work and viva voce examination at the end of the third semester. The same procedure will be adopted for thesis Phase II in the fourth semester.

11. Student Counsellors (Mentors)

To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counsellor for those students throughout their period of study. Such student counsellors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester, monitor their progress in SWAYAM courses / open elective courses and obtain the final approval of the Head of the Department.

12. Class Committee

For each of the semesters of M.E / M.Techprogrammes, separate class committees will be constituted by the respective Head of the Departments. The composition of the class committees from first to fourth semesters for Full time and first to sixth semesters for Part-time will be as follows:

- Teachers of the individual courses.
- A Thesis coordinator (for Thesis Phase I and II) shall be appointed by the Head of the Department from among the Thesis supervisors.
- A thesis review committee chairman shall be appointed by the Head of the Department
- One Professor or Associate Professor, preferably not teaching the concerned class, appointed as Chairman by the Head of the Department.
- The Head of the Department may opt to be a member or the Chairman.
- All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

The class committee shall meet **three** times during the semester. The first meeting will be held within two weeks from the date of class commencement in which the type of assessment like test, assignment etc. for the third assessment and the dates of completion of the assessments will be decided.

The second meeting will be held within a week after the completion of the first assessment to review the performance and for follow-up action.

The third meeting will be held after all the assessments but before the University semester examinations are completed for all the courses, and at least one week before the commencement of the examinations. During this meeting the assessment on a maximum of 25 marks for theory / 40 marks for practical and project work will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

13. Temporary Break Of Study

A student can take a one-time temporary break of study covering the current semester and / or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the mid-semester test. However, the student must complete the entire programme within the maximum period of **four years for Full time / six years for Part time.**

14. Substitute Assessments

A student who has missed, for genuine reasons accepted by the Head of the Department, one or more of the assessments of a course other than the end of semester examination may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the third meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.

15. Attendance Requirements

The students with 75% attendance and above are permitted to appear for the University examinations. However, the Vice Chancellor may give a rebate / concession not exceeding 10% in attendance for exceptional cases only on Medical Grounds.

A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register and repeat the same semester in the subsequent academic years.

16. Passing anddeclaration of Examination Results

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. Thereafter, the controller of examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average (GPA) and cumulative grade point average (CGPA) and prepare the mark sheets.

90 to 100 marks	Grade ‘S’
80 to 89 marks	Grade ‘A’
70 to 79 marks	Grade ‘B’
60 to 69 marks	Grade ‘C’
55 to 59 marks	Grade ‘D’
50 to 54 marks	Grade ‘E’
Less than 50 marks	Grade ‘RA’
Withdrawn from the Examination	Grade ‘W’

A student who obtains less than 30 / 24 marks out of 75 / 60 in the theory / practical examinations respectively or is absent for the examination will be awarded grade RA.

A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.\

A student who obtains letter grade RA / W in the mark sheet must reappear for the examination of the courses.

The following grade points are associated with each letter grade for calculating the grade point average and cumulative grade point average.

S - 10; A - 9; B - 8; C - 7; D - 6; E - 5; RA - 0

Courses with grade RA / W are not considered for calculation of grade point average or cumulative grade point average.

A student can apply for re-totaling of one or more of his examination answer papers within a week from the date of issue of mark sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After the results are declared, mark sheets will be issued to the students. The mark sheet will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester.

CGPA is similarly calculated considering all the courses taken from the time of admission.

17. Awarding Degree

After successful completion of the programme, the degree will be awarded with the following classifications based on CGPA.

For First Class with Distinction the student must earn a minimum of 65 credits within four semesters for full-time / six semesters for Part time from the time of admission, pass all the courses in the first attempt and obtain a CGPA of 8.25 or above.

For First Class, the student must earn a minimum of 65 credits within two years and six months for full-time / three years and six months for Part time from the time of admission and obtain a CGPA of 6.75 or above.

For Second class, the student must earn a minimum of 65 credits within four years for full-time / six years for Part time from the time of admission.

18. Ranking Of Candidates

The candidates who are eligible to get the M.E /M.Techdegree in First Class with Distinction will be ranked on the basis of CGPA for all the courses of study from I to IV semester for M.E / M.Tech full-time / I to VI semester for M.E / M.Tech part-time.

The candidates passing with First Class and without failing in any subject from the time of admission will be ranked next to those with distinction on the basis of CGPA for all the courses of study from I to IV semester for full-time / I to VI semester for M.E / M.Tech part-time.

19. Transitory Regulations

If a candidate studying under the old regulations M.E. / M.Tech could not attend any of the courses in his/her courses, shall be permitted to attend equal number of courses, under the new regulation and will be examined on those subjects. The choice of courses will be decided by the concerned Head of the department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time.

ANNEXURE 1

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.TechProgramme *
1	**Civil Engineering**	i.	Environmental Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Industrial Engg, Chemical Engg, BioChemicalEngg, Biotechnology, Industrial Biotechnology, Chemical and Environmental Engg.
		ii.	Environmental Engineering & Management	
		iii.	Water Resources Engineering & Management	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Agricutural and irrigation Engg, Geo informatics, Energy and Environmental Engg.
2	**Civil & Structural Engineering**	i.	Structural Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg.
		ii.	Construction Engg. and Management	
		iii.	Geotechnical Engineering	
		iv.	Disaster Management &Engg.	
3	**Mechanical Engineering**	i.	Thermal Power	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical Engg (Manufacturing).
		ii.	Energy Engineering & Management	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical (Manufacturing) Engg, Chemical Engg
4	**Manufacturing Engineering**	i.	Manufacturing Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Mechatronics Engg and Industrial Engg.
		ii.	Welding Engineering	
		iii.	Nano Materials and Surface Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Chemical Engg
5	**Electrical Engineering**	i.	Embedded Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Information technology, Electronics and communication Engg, Computer Science and Engg
		ii.	Smart Energy Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Electronics and communication Engg,
		iii.	Power System	

6	**Electronics & Instrumentation Engineering**	i.	Process Control & Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Control and Instrumentation Engg, Instrumentation Engg
		ii.	Rehabilitative Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics.
		iii.	Micro Electronics and MEMS	B.E. / B.Tech – B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg
7	**Chemical Engineering**	i.	Chemical Engineering	B.E. / B.Tech – Chemical Engg, Petroleum Engg, Petrochemical Technology
		ii.	Food Processing Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Biochemical Engg, Agricultural Engg.
		iii.	Industrial Bio Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Leather Technology
		iv.	Industrial Safety Engineering	B.E. / B.Tech – Any Branch of Engineering
8	**Computer Science & Engineering**	i.	Computer Science & Engineering	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
9	**Information Technology**	I	Information Technology	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
10	**Electronics & Communication Engineering**	i.	Communication Systems	B.E. / B.Tech -Electronics and Communication Engg, Electronics Engg.

*** AMIE in the relevant discipline is considered equivalent to B.E**

DEPARTMENT OF ELECTRONICS and INSTRUMENTATION ENGINEERING
Curriculum for M.E.(Process Control and Instrumentation) – Full Time

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – I										
1	PC-I	PCIC 101	Applied Mathematics	4		-	25	75	100	3
2	PC-II	PCIC 102	System Theory	4		-	25	75	100	3
3	PC-III	PCIC 103	Process Dynamics and Control	4		-	25	75	100	3
4	PC-IV	PCIC 104	Industrial Instrumentation	4		-	25	75	100	3
5	PE-I	PCIE 105	Professional Elective – I	4		-	25	75	100	3
6	PE-II	PCIE 106	Professional Elective – II	4		-	25	75	100	3
7	PC Lab-I	PCIP 107	Process Control and Instrumentation Lab	-	-	3	40	60	100	2
			Total	**24**	**-**	**3**	**190**	**510**	**700**	**20**

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – II										
1	PC-V	PCIC 201	Industrial Data Communication and Control	4	-	-	25	75	100	3
2	PC-VI	PCIC 202	Instrumentation System Design	4	-	-	25	75	100	3
3	PC-VII	PCIC 203	Advanced Process Control	4	-	-	25	75	100	3
4	PC-VIII	PCIC 204	Process Data Analytics	4	-	-	25	75	100	3
5	PE-III	PCIE 205	Professional Elective – III	4	-	-	25	75	100	3
6	PE-IV	PCIE 206	Professional Elective – IV	4	-	-	25	75	100	3
7	PC Lab-II	PCIP 207	Automation Lab	-	-	3	40	60	100	2
8	Semin	PCIS 208	Seminar	-	-	2	100	-	100	1
			Total	**24**	**-**	**5**	**290**	**510**	**800**	**21**

Sl. No.	Cate gory	Course Code	Course	L	T	P	CA	FE	Total	Credits
Semester – III										
1	OE-I	PCIE 301	Open Elective – I	4	-	-	25	75	100	3
2	OE-II	PCIE 302	Open Elective – II	4	-	-	25	75	100	3
3	Thesis	PCIT 303	Thesis Phase-I	-	4	-	40	60	100	4
4	IndTrain	PCII 304	Industrial Training		*	-	100	-	100	2
			Total	**8**	**4**	**-**	**190**	**210**	**400**	**12**

Note: * - Four weeks during the summer vacation at the end of IInd Semester.

Sl. No.	Cate gory	Course Code	Course	L	T	P	CA	FE	Total	Credits
Semester – IV										
1	Thesis	PCIT 401	Thesis Phase-II	-	8	-	40	60	100	12
			Total	**-**	**8**	**-**	**40**	**60**	**100**	**12**

L: Lecture , **P:** Practical, **T**: Thesis**, CA:** Continuous Assessment, **FE:** Final Examination

M.E. (Process Control and Instrumentation) DEGREE PROGRAMME
(PART TIME)
Choice Based Credit System(CBCS)
Courses of Study and Scheme of Examination

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – I											
1	PC-I	PPCIC 101	Applied Mathematics	4	-	-	25	75	100	3	PCIC 101
2	PC-II	PPCIC 102	System Theory	4	-	-	25	75	100	3	PCIC 102
3	PC-III	PPCIC 103	Process Dynamics and Control	4	-	-	25	75	100	3	PCIC 103
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – II											
1	PC-IV	PPCIC 201	Industrial Data Communication and Control	4	-	-	25	75	100	3	PCIC 201
2	PC-V	PPCIC 202	Instrumentation System Design	4	-	-	25	75	100	3	PCIC 202
3	PC-VI	PPCIC 203	Advanced Process Control	4	-	-	25	75	100	3	PCIC 203
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – III											
1	PC-VII	PPCIC 301	Industrial Instrumentation	4	-	-	25	75	100	3	PCIC 104
2	PE-I	PPCIE 302	Professional Elective – I	4	-	-	25	75	100	3	PCIE 105
3	PE-II	PPCIE 303	Professional Elective – II	4	-	-	25	75	100	3	PCIE 106
4	PC Lab-I	PPCIP 304	Process Control and Instrumentation lab.	-	-	3	40	60	100	2	PCIP 107
			Total	**12**	**-**	**3**	**115**	**285**	**400**	**11**	

S.No	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – IV											
1	PC-VIII	PPCIC 401	Process Data Analytics	4	-	-	25	75	100	3	PCIC 204
2	PE-III	PPCIE 402	Professional Elective – III	4	-	-	25	75	100	3	PCIE 205
3	PE-IV	PPCIE 403	Professional Elective – IV	4	-	-	25	75	100	3	PCIE 206
4	PC Lab-II	PPCIP 404	Automation Lab	-	-	3	40	60	100	2	PCIP 207
5	Semin	PPCIS 405	Seminar		-	2	100		100	1	PCIS208
			Total	**12**	**-**	**5**	**215**	**285**	**500**	**12**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – V											
1	OE-I	PPCIE 501	Open Elective – I	4	-	-	25	75	100	3	PCIE 301
2	OE-II	PPCIE 502	Open Elective – II	4	-	-	25	75	100	3	PCIE 302
3	Thesis	PPCIT 503	Thesis Phase-I	-	4	-	40	60	100	4	PCIT 303
4	Indus Train	PPCII 504	Industrial Training		*	-	100		100	2	PCII304
			Total	**8**	**4**	**-**	**190**	**210**	**400**	**12**	

Note: * - Four weeks during the summer vacation at the end of IVth Semester.

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – VI											
1	Thesis	PPCIT 601	Thesis Phase-II	-	8	-	40	60	100	12	PCIT 401
			Total	**-**	**8**	**-**	**40**	**60**	**100**	**12**	

L: Lecture ,**P:** Practical,**T**: Thesis, **CA:** Continuous Assessment;**FE:** Final Examination

LIST OF ELECTIVES

S.No	Professional Elective
1	Advanced Digital Signal Processing
2	Embedded Systems
3	Machine Learning Techniques
4	Optimal Control
5	Advanced Instrumentation Systems
6	Adaptive Control
7	Fault Tolerant Control
8	Statistical Process Control
9	MEMS Design and Fabrication
10	Automotive Instrumentation

S.No	Open Elective
1	Industrial Drives and Control
2	Wireless Sensor Networks
3	VLSI System Design
4	Digital Image Processing
5	Multi sensor Data Fusion
6	Bio Signal Processing

PCIC 101	APPLIED MATHEMATICS	L	T	P
		4	0	0

COURSE OBJECTIVES

- To formalise knowledge of the theory of probability and random variables.
- To present methods of solving systems of linear equations and vector spaces.
- To cover a variety of different problems in Graph Theory.

Probality Theory :
Probability – Baye's Theorem for conditional probability – random variable – attribution function – Density function – variance bivariate distribution – covariance – correlation - Regression. Marginal and conditional distribution.

Random Process: stochastic process – classification,auto correction and auto co-variance – cross correlation – stationery process. Markov chains: Definition and example – higher transition probabilities – classification of states and chains.

Linear Algebra and Vector Space:
Linear system of equation – consistency – test for consistency – linear dependence and independence of vectors – vector space – Bases and dimension – subspace – Inner product space – orthonormal basis – gram – Schmitt orthogonalization process.

Numerical Solution of Partial Differential Equations:
Elliptic equation – Poisons equation and Laplace equation – liebmann iterative method. Hyperbolic equation; one-dimensional wave equation and radio equation – Parabolic equation – one-dimensional heat equation and telegraph equation – bender – Schmidt method – crank Nicolson method.

Topics in Graph Theory:
Graphs – Eular paths and circuits, Hamiltonian paths and circuits – trees – undirected trees – spanning trees and minimal spanning trees.

REFERENCES

1. Gupta.SC and Kapoor VK. Fundamentals of mathematical statistics, Sultan Chand and sons.
2. Louis A Pipes, Applied mathematics for Enginners and physists, McGraw-Hill.
3. Hoffman and Kanz – Linear Algebra , PHT.
4. N. Deo – Graph Theory, TMH India.
5. M.K. Venkatraman – Numerical methods.
6. J. Medhi – Statistic process – Wiley Eastern Ltd.

COURSE OUTCOMES

Upon completing the course, the student will be able to

1. Understand the formulation of modern Probability Theory and random variables as an intrinsic need for the analysis of random phenomena.
2. Use the techniques and theory of linear algebra to model various real world problems.
3. Apply vectors in higher dimensional space in experimental data.
4. Use matrix in graph theory, linear combinations of quantum state in in various fields of engineering.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2	✓			✓	✓
CO3	✓				
CO4	✓				✓

PCIC 102	**SYSTEM THEORY**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To impart knowledge on modeling and representing systems in state variable form.
- To educate on solving linear and non-linear state equations and to illustrate the role of controllability and observability.
- To provide an overview on modal concepts and design of state feedback and state estimators.
- To introduce the concept of Non linear systems and apply describing function Techniques.
- To educate on stability analysis of systems using Lyapunov's theory.

Mathematical descriptions of systems: Transfer function matrix - state space representation using physical, phase and canonical variables - comparison of input-output description and state variable description - mathematical description of composite systems.

Solution of dynamical equation: state transition matrix - impulse response matrix- controllability and observability- linear independence of time functions – Canonical form dynamical equations for single variable and multivariable cases - irreducible dynamical equation - controllability and observability of Jordan form dynamical equation - output controllability.

State feedback: Effects of state feedback, pole placement and feedback gain matrix- State estimators: Full-dimensional state estimator – reduced dimensional state estimator - connection of state feedback and state estimator - decoupling by state feedback.

Non–linear Systems: Behaviour of non-linear systems, jump resonance, subharmonic oscillation- Phase plane analysis: Singular points - construction of phase portraits using isocline, Lienard, Delta and Pells method - limit cycle analysis. Describing Function Techniques: Describing Function of nonlinearities - gain function and its determination for analytically and graphically defined nonlinearities- conditions for stability - stability of oscillation - accuracy of Describing Function method - stability of systems with multiple nonlinearities – closedloop frequency response

Stability analysis: Stability in the sense of Liapunov - second method of Liapunov - Liapunov stability analysis of linear time invariant systems and non linear system- Krasovski's theorem- variable gradient method of generating Liapunov functions.

REFERENCES

1. Chen. C.T., Linear System Theory and Design, Oxford University Press, 4th Edition, 2013.
2. Gopal. M., Modern Control System Theory, RevisedEdition, New Age International, 1993.
3. Digital Control and State Variable Methods: Conventional and Neural-fuzzy Control Systems, Tata McGraw-Hill Education, 2003.
4. Houpis.C.H, Digital Control System- theory, Hardware and Software, McGraw-Hill Series in Electrical Engineering, 2014.
5. Katsuhiko Ogata, Modern Control Engineering, Pearson, 5th Edition, 2009.
6. Gibson, J.E, Nonlinear Automatic Control, McGraw Hill Book Co, 1963.
7. Cunningham, W.J., Introduction to Nonlinear Analysis McGraw Hill, 1958.
8. D'Azzo J.J and Houpis. C.H., Linear Control System –Analysis & Design , McGraw Hill, III edition, 1988.

COURSE OUTCOMES

Upon completing the course, the student should

1. Understand basic principles of Transfer function model and State space model.
2. Acquire knowledge of state transition matrix, Controllability and Observability.
3. Understand the concepts of state feedback and state estimators.
4. Analyze Non linear systems and apply Describing Function Techniques.
5. Able to check and analyze stability of linear and non linear systems.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2	✓	✓			
CO3	✓	✓	✓		✓
CO4	✓	✓		✓	
CO5	✓	✓			✓

PCIC 103	PROCESS DYNAMICS AND CONTROL	L	T	P
		4	0	0

COURSE OBJECTIVES

- To introduce the dynamics of various processes and modelling of physical process using first principles.
- To get adequate knowledge about basic control actions and related issues.
- To educate the effect of various control actions and the methods of tuning the controller.
- To introduce the concept of MIMO process and its control schemes.
- To study the control schemes for typical processes and its P&ID diagram.

Process control: Design aspects – Hardware elements of process control system. Mathematical modeling of processes: Fundamental laws and equations – level, thermal, flow, gas and mixing process. Interacting and non-interacting process – self-regulation-inverse response – degrees of freedom – linearization – transfer function representation of process – variable gain, variable time constant.

Feedback control of processes: Basic control actions – characteristics of ON/OFF, P, P+I, P+D, P+I+D control modes – non-linear PID control – position and velocity forms of PID controllers - anti-reset windup – bumpless transfer – practical forms of P+I+D control modes, selection of control modes for different processes – control schemes for flow, level, pressure and temperature. Methods of controller tuning, Ziegler – Nichols continuous cycling, damped oscillations, process reaction curve method – Cohen and Coon method, time – integral criteria.

Advanced control systems: Feedback control of systems with large dead time, dead time compensation – Cascade control – feed forward and ratio control – Adaptive and inferential control systems – internal model control - Model predictive control – Introduction to schemes of MPC.

Design of control systems for multivariable process: Design equations-degrees of freedom-poles and zeros - number of controlled and manipulated variables – generation of alternative loop configurations-extension to systems with interacting units. Interaction of control loops – relative gain array – selection of loops – design of non – interacting control loops. Decoupling control.

Control of typical processes: Distillation column, control of top and bottom product composition, reflux ratio. CSTR, Four-tank system and PH process. piping and Instrumentation Drawing (P&ID) of control loops.

REFERENCES

1. Ramesh C Panda and T. Thyagarajan, An Introduction to Process modelling, Identification and control for Engineers, Narosa Publishing House, First edition, 2017.
2. B. WaynBequette, Process Control: Modeling, Design and Simulation,Prentice Hall International series, Third edition, 2003.

3. George Stephanopoulos, Chemical Process Control, An Introduction to the Theory and Practice, Prentice Hall International Inc., First edition, 2008.
4. Donald R.Coughanowr, Process Systems Analysis and Control, Third Edition, McGraw-Hill Inc., 2013.
5. Peter Harriott, Process Control, Tata McGraw Hill 26th Reprint, 2005.
6. M.Chidambaram, Applied Process Control, Narosa Publishers 2002.
7. D. Patranabis, Principles of Process Control, Tata McGraw Hill, Third Edition, 2013.
8. William L Luyben, Michael L Luyben, Essentials of Process Control, Tata McGraw Hill, 1997.
9. Curtis D Johnson, Process Control Instrument Technolgy, Prentice Hall of India, Eighth edition, 2005.

COURSE OUTCOMES

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

1. Understand basic principles and importance of process control in industrial process plants.
2. Acquire knowledge of dynamic modelling and system behaviour.
3. Understand the need for mathematical basis for the design of control systems.
4. Design and implementation of advanced controllers.
5. Understand the concept of MIMO process.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓				
CO2	✓	✓			
CO3	✓	✓			
CO4		✓	✓	✓	
CO5	✓				

PCIC 104	**INDUSTRIAL INSTRUMENTATION**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To impart knowledge about the various techniques used for the measurement of primary industrial parameters like flow, level, temperature and pressure.
- To make the students understand about the important parameters to be monitored and analyzed in Thermal power plant and Nuclear power plant.
- To get an exposure on the important parameters to be monitored and analyzed in Petrochemical Industry.
- To learn about the intrinsic safety techniquesadapted in industries.

- To familiarize the students about the safety instrumented system and method to evaluate risk and safety instrumentation levels.

Measurement of important process variables:
Measurement principles of Temperature, Pressure, Level and Flow measuring instruments - General Considerations for Instrument mounting- Calibration principles for temperature and pressure transmitters- Semiconductor transducers for Temperature, Pressure, Level, and Flow.

Instrumentation for Thermal power plant:
Measurement of fuel flow, Air flow, Drum level, Steam pressure, Steam temperature - Selection and Installation of instruments for these variables -Dissolved oxygen analyzer -Flue gas analyzer -pH analyzer - Coal /oil analyzer - Pollution instruments-Dust monitor.

Instrumentation for Nuclear power plant:
Nuclear Radiation Sensors- Out of Core–Neutron Sensors-In Core – Process Instrumentation: Temperature Sensing, Pressure Sensing and transmitting, Flow Sensing, Level and Position Sensing, Steam Properties Sensing, Water Properties Sensing, Gas Properties Sensing – Special sensor for Sodium cooled reactors and gas cooled reactors.

Instrumentation for Petro chemical industry/Refinery:
Selection and installation of instruments for the measurement of temperature, level, flow and pressure in refinery – Measurements in Pyrolysis, Catalytic cracking and reforming processes-Hydrocarbon analyser-Sulphur in oil analyzer.

Instrumentation for Industrial Safety:
Intrinsic safety: Definition - Conservation and emergency vents - Flame, Fire and Smoke detectors - Leak detectors - Metal detectors.Safety Instrumentation System (SIS): need, features, components, difference between basic processcontrol system and SIS.

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

REFERENCES

1. D.Patranabis, “Principles of Industrial Instrumentation”, 3rd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2010.

2. B.G.Liptak, “Instrumentation Engineers Handbook (Measurement)”, Fourth Edition, Volume 1, CRC press, 2005.

3. Singh, S.K., “Industrial Instrumentation and Control”, Tata McGraw Hill Education Pvt. Ltd., NewDelhi, 2009.

4. Jones, B.E., “Instrument Technology”, Vol.2, Butterworth-Heinemann, International Edition, 2003.

5. Donald P.Eckman, Industrial Instrumentation, Wiley Eastern Limited, 1991.

6. Doebelin, E.O.andManik,D.N., “Measurement Systems Application and Design”, 5th Edition, Tata McGraw Hill Education Pvt. Ltd., 2007.

7.Samuel Glasstone and Alexander Sessonske, ”Nuclear Reactor Engineering”, CBS publishers and Distributors Pvt. Ltd., 2004.
8. Paul Gruhn and Harry L. Cheddie,” Safety Instrumented systems: Design, Analysis and Justification”, ISA, 2nd Edition, 2006.
9.Eric W. Scharpf, Heidi J. Hartmann, Harlod W. Thomas, “Practical SIL target selection: Riskanalysis as per the IEC 61511 safety Lifecycle”, Exida, 2012.
10. Gill, A.B., “Power Plant performance”, Butterworth and Co (Publishers) Ltd, 2003.
11. NPTEL Video Lectures on “Nuclear Reactors and Safety - An Introduction” by Dr. G. Vaidyanathan.
12. AlokBarua, “Lecture Notes on Industrial Instrumentation”, NPTEL, E-Learning Course, IIT Kharagpur.

COURSE OUTCOMES

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

1. Apply knowledge on measurement and calibration principles of basic industrial process variablesto ensure proper functioning of industrial systems.
2. Appropriately select and mount the instruments for a particular process.
3. Execute instrumentation requirements in various process industries such as Thermal power plant and Nuclear power plant and Petro Chemical/ Refinery.
4. Identify hazardous area and ensure safety measures by evaluating risk levels and features.
5. Design and implement a safety instrumentation system.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓	✓		
CO2	✓	✓	✓		
CO3			✓	✓	✓
CO4				✓	✓
CO5				✓	✓

PCIC 107	**PROCESS CONTROL AND INSTRUMENTATION LAB**	**L**	**T**	**P**
		0	**0**	**3**

COURSE OBJECTIVES

- To impart knowledge about the modelling principle of level process and the characteristics of final control element and Controller.
- To design and implement tuning techniques of PID controller and verify in Matlab/Simulink environment.

- To design and implement closed loop control for processes like Air temperature, Air flow and Level.
- To familiarize the students with design and simulate cascade control for the given process.
- To Study the applications of Programmable Logic Controller.

LIST OF EXPERIMENTS

1. Determination of Control Valve characteristics
2. Determination of characteristics of capacitive level transmitter
3. Controller tuning using Continuous Cycling method
4. Modeling of an industrial Air Temperature Process
5. Study of Air flow control system and determination of transfer characteristics of I/P converter, Control Valve and Flow transmitter
6. Controller tuning using Process Reaction Curve method
7. Modeling and simulation of a Level process using TUTSIM
8. Determination of characteristics of a PID controller using MATLAB (Simulink) software
9. Determination of Transfer function (Experimental model) of Level process
10. Design and simulation of Averaging Control

COURSE OUTCOMES

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

1. To model and design controllers for different processes.
2. To design and implement advanced control techniques.
3. Familiarize with TUTSIM and MATLAB software for process control applications.

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		
CO2	✓	✓	✓		
CO3				✓	

PCIC 201	INDUSTRIAL DATA COMMUNICATION AND CONTROL	L	T	P
		4	0	0

COURSE OBJECTIVES

- To provide fundamental knowledge about industrial data acquisition system and different industrial networking standards.
- To provide comprehensive knowledge about the methods of internetworking.
- To give basic knowledge in the architecture and local control unit of distributed control system.

- To give adequate information about SCADA, PLC and OPC.
- To give basic knowledge about HART, field bus, and control network technology.

Data Acquisition Systems(DAS): Review of A/D and D/A Converters - Sampling and digitizing - Review of Analog Communication Systems and techniques - multiplexing –TDM & FDM- Data Communication - transmission lines and digital signals - practical line interface circuits - serial asynchronous communication protocol - Intel 8251A - current loop, RS 232 C- RS 485 - GPIB – USB, Bluetooth.

MODEM: Data coding methods - error detection, correction and encryption. Fiber Optic transmission - Optical fiber Cables - light sources and detectors. Architecture of a PLC – Analog and digital types of I/O modules – PLC system memories - Program and data organization inside a PLC - Networking of multiple PLC.

Methods of Computer Control of Processes, their configuration and comparison: Direct Digital Control, Supervisory Digital Control, Distributed Control System (DCS).

DCS :- Local Control Unit(LCU) and architecture - LCU languages - LCU - Process interfacing issues. Operator interface - requirements Engineering interface - requirements - displays - alarms and alarm management. Factors to be considered in selecting a DCS. Introduction to SCADA, OLE for Process control(OPC).

Network topology and media : OSI model - Data link Control protocol. Media access protocol: Command/response - Token passing - CSMA/CD, TCP/IP. Bridges - Routers - Gateways. Standard ETHERNET and Industrial ETHERNET Configuration - Special requirement for networks used for Control, Wireless LAN. Introduction to MODBUS, CANBUS, LON WORKS, FIP.

Protocols:HART: Introduction - Evolution of Signal standard - HART Communication protocol - Communication modes - HART Commands – HART and the OSI model.

Field Bus: Introduction - General Field bus architecture - basic requirements of field bus standard - field bus topology - Interoperability - Interchangeability.

REFERENCES

1. Behrouz A. Forouzan, Data communications and Networking, Tata Mcgraw Hill, 2004.
2. Frank Petruzella, Programmable Logic Controllers, 5th Edition, McGraw-Hill, 2017.
3. William L. Schweber, Data Communications, McGraw-Hill, 1988.
4. NPTEL Notes on, “Programmable Logic Control System” by Department of Electrical Engg., IIT Kharagpur.
5. Yokogawa – CS 3000, Fundamental Training manual, 2009.
6. Romilly Bowden, HART Application Guide, HART Communication Foundation, 1999.
7. BG Liptak, Instrument Engineer Handbook- Process software and Digital Networks, 3rd Edition.

COURSE OUTCOMES

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

1. Understand the basic principle and modes of digital data transmission and communication.
2. Understand the various types of buses and devices used for data communication in industry.
3. Implement the automation concepts in a process industry like DCS and PLC.
4. Understand different networking topologies for data communication in process industries.
5. Use HART and FiledBus protocols for process industries.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓	✓		✓
CO3				✓	✓
CO4			✓	✓	
CO5				✓	✓

PCIC 202	**INSTRUMENTATION SYSTEM DESIGN**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To make the students familiarize design orifice and control valve sizing.
- To impart knowledge on the design of signal conditioning circuits for the measurement of Level and temperature.
- To develop the skills needed to design and test Analog/ Digital PID controller, Data Acquisition System and Alarm Annunciator.

Orifice meter - design of orifice for given flow condition - design of rotameter. Control valves - design of actuators and positioners - valve characteristics - sizing of control valves - Liquid, Gas and steam services.

Design of V-I, I-V ,P-I and I-P converters. Analog and Digital filter design and Adaptive filter design – Design of signal conditioning circuits for Air purge system for level measurement - Design of signal conditioning circuits for Temperature measurement-RTD Thermocouple and thermistor.

Design of cold junction compensation circuit for thermocouple using RTD. Transmitters - zero and span adjustment in D/P transmitters - Temperature transmitters- Design of RTD based Temperature Transmitter, Thermocouple based Temperature Transmitter, Capacitance based Level Transmitter and Smart Flow Transmitters. Design of flapper-nozzle and design of Pneumatic amplifiers.

Design of ON / OFF Controller using Linear Integrated Circuits- Electronic P+I+D controllers - design - adjustment of set point, bias and controller settings- Design of microprocessor based P+I+D controller - Design of microprocessor based system for data acquisition.

Design of Alarm and Annunciation circuits using analog and digital circuits – Design of Programmable Logic Controller - Design of configurable sequential controller using PLDs.

REFERENCES

1. C.D. Johnson, Process Control Instrumentation Technology, Prentice Hall of India, 8th Edition, 2014.
2. J.P.Bentley, Principles of Measurement Systems, Longman Inc., 1983.
3. N.A.Anderson, Instrumentation for Process Measurement and Control, Chilton Company, 1997.
4. D.M.Considine, Process Instruments and Controls Handbook, McGraw-Hill., Fourth Ediion, 1994.

COURSE OUTCOMES

1. Ability to carryout orifice and control valve sizing for Liquid/Steam Services.
2. Ability to design signal conditioning circuits for temperature sensors, V/I , I/V P/I and I/P converters.
3. Ability to design transmitters.
4. Ability to design, fabricate and test PID controllers and alarm circuits.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓				
CO2	✓	✓		✓	
CO3	✓	✓		✓	
CO4			✓	✓	✓

		L	T	P
PCIC 203	**ADVANCED PROCESS CONTROL**	**4**	**0**	**0**

COURSE OBJECTIVES

- To review the processes with special characteristics.
- To study the fundamentals design and implementation of MPC.
- To study the concept of robust control system.
- To design and analyse optimal controllers.

- To understand and design controllers for MIMO process.

Introduction to process control:Review of first order and higher order systems, self and non-self regulatory processes, inverse response processes, non-minimum phase processes and open-loop unstable processes. Response to step, impulse and sinusoidal disturbances. Review of design and implementation of PID controller.

Model based predictive control: MPC strategy – MPC elements – prediction models – objective function – obtaining the control law – review of some MPC algorithms – Introduction to Non-linear predictive control.Implementation of Model Predictive Control for Heat exchanger and Distillation column.

Robust control:Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – vector Random spaces- Specification for feedback systems – Co-prime factorization and Inner functions –structured and unstructured uncertainty- robustness Synthesis of Robust Controllers – Small Gain Theorem – D-K –iteration- Robust Control of Second-order Plant-Robust Control of Distillation Column.

Optimal controllers:H2 and H-INFINITY control – loop shaping design -Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – Hinfinity estimation. LQG controller.

Design of controllers for MIMO processes: Introduction to Multivariable process control – selection of controlled outputs manipulation and measurements – RGA for square and non-square plants – Control configuration elements – centralized and decentralized feedback control – Trade-offs in MIMO feedback design.

REFERENCES

1. Sigurdskogestad Ian postlethwaite, Multivariable Feedback Control, John wiley& sons, 2000.
2. Jurgen Ackermann, Robust Control Sytsems with uncertain physical parameters, third edition, Springer – Verlog London limited, 1997.
3. E.F.Camacho and Bordom, Model Predictive Control, Second edition, Springer – Verlog London limited, 2000.
4. U. Mackenroth “Robust Control Systems: Theory and Case Studies”,Springer international Edition, 2010.
5. J. B. Burl, “ Linear optimal control H2 and H-infinity methods”, Addison W Wesley, 2011.
6. D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances In Design and Control”, Society for Industrial and Applied Mathematics, 2007.
7. I.R. Petersen, V.A. Ugrinovskii and A. V. Savkin, “Robust Control Design using H-infinity Methods”, Springer, 2000.

8. M. J. Grimble, "Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems", John Wiley and Sons Ltd., Publication, 2006.

COURSE OUTCOMES

1. Able to analyse system behaviour.
2. Able to understand and design MPC for a given process.
3. Ability to design robust control system.
4. Able to understand the concept of H2 and H∞ controller.
5. Able to understand and design a Multi-Input Multi-Output system.

	PO1	PO2	PO3	PO4	PO5
CO1		✓			
CO2	✓	✓		✓	
CO3		✓	✓		✓
CO4	✓	✓			
CO5				✓	

PCIC 204	PROCESS DATA ANALYTICS	L	T	P
		4	0	0

COURSE OBJECTIVES

- To impart knowledge on various Non parametric approaches based system identification.
- To make the student understand the principles of State space modelling of linear and nonlinear systems.
- To know Non recursive and recursive parametric identification approaches.
- To learn to develop Robust parametric identification methods.
- To impart knowledge pertaining to practical aspects of system identification and control.

Process Identification (Non-Parametric methods): Transient response analysis - frequency response analysis - correlation analysis - State space modeling of systems - Nonlinear state space model and linearization of nonlinear models ; Modeling in state space - state space models – canonical state space forms- mechanical systems –Electrical systems – Liquid level systems- Thermal systems. State estimation using Kalman Filter-extended Kalman filter – unscented kalman filter-ensemble kalman filter for parameter Identification.

Discrete time system models for control: ARX models - bilinear parametric models – ARMAX,OE,BJ models - Hammerstein models – Wienner model –prediction error method and instrumental variable method . Selection of pseudo random binary sequence. **Recursive Plant Model identification in open-loop**: Identification methods - least squares - recursive least squares - extended least squares – generalized least squares –weighted LSE-maximum likelihood method - model validation identified in open-loop – Model order selection.

Recursive plant model identification in closed-loop:Identification methods - closed-loop output error algorithms - filtered closed-loop error algorithms - filtered open-loop identification algorithms - model validation identified in closed-loop - comparative evaluation of various algorithms. Subspaces identification method: classical and innovation forms, free and structures parameterizations- relay feedback identification of stable processes and unstable processes.

Nonlinear system identification: Modeling of non linear system using ANN- NARX, NNSS,NARMAX- generation of training data – training Feed-Forward and Recurrent Neural Networks- TSK model- Adaptive Neuro-Fuzzy Inference system(ANFIS), Practical aspects of System identification and control: Selection of input signals - offline and online identification; notion for persistent excitation,drifts and de-trending-outliers and missing data-pre-filtering-robustness – comparison of parameter estimation methods – model order testing and verification-case studies.

REFERENCES

1. Ioan D. Landau and GianlucaZito, Digital Control Systems, Design, Identification and Implementation, Springer-Verlag London Limited 2006.
2. Dan Simon, "Optimal State Estimation Kalman,H-infinity and Non-linear Approaches", John Wiley and Sons, 2006.
3. Arun K. Tangirala, " Principles of System Identification: Theory and Practice", CRC Press. 2014.
4. F.Van der Heijden, R.P.W.DUIN, D.de Ridder and D.M.J. Tax, "Classification, Parameter Estimation and State Estimation , An Engineering Approach Using MATLAB, John Wiley & Sons Ltd. 2004.
5. W.T.Miller, R.S.Sutton and P.J.Webrose, " Neural Networks for Control",MIT Press,1995.

COURSE OUTCOMES

1. Will be able to identify a suitable continuous time domain identification method for the taken up process.
2. Ability to select particular state space model based on specific control engineering problem.
3. Understand and implement the various complexity estimation methods, offline and online, open and closed loop estimation methods for modelling and estimating a process.
4. Gain an idea for Robust parameter estimation.
5. Select a specific identification method with an approximately equal complexity for the case studies.

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓			
CO2		✓	✓	✓	
CO3	✓	✓	✓		✓
CO4		✓		✓	
CO5				✓	✓

PCIP207	**AUTOMATION LAB**	**L**	**T**	**P**
		0	**0**	**3**

COURSE OBJECTIVES

- To impart knowledge about different digital Controller desgin.
- To design and implement tuning techniques of PID controller and verify in Matlab/Simulink environment.
- To design and implement closed loop control for processes like Air temperature, Air flow and Level using LABVIEW software.
- To familiarize the students with different logics in PLC and its implementation for automation applications.
- To study the applications of SCADA and DCS for process automation applications.

LIST OF EXPERIMENTS

1. Design and Simulation of Dead-beat controller using TUTSIM
2. a) Design of Dead time compensator using smith predictor algorithm using MATLAB/SIMULINK
   b)Design and Simulation of Inverse response compensator using MATLAB/SIMULINK
3. Study of LABVIEW software
4. a) Study of Programmable Logic controller (Keyence PLC)
   b)Direction Control of DC motor using PLC
5. Study of SCADA software (Intouchwonderware)
6. PC based control of a simulated process
7. Design of Fuzzy &Neuro controller for a Pressure Process
8. Study of DCS (Centum CS 3000)

COURSE OUTCOMES

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

1. To model and design digital controllers for different processes.
2. To design and implement artificial intelligence based control techniques.
3. Get hands on experience for PLC interfacing with real time applications.
4. Familiarize with LabView and SCADA software for process control applications.

PCIS208	SEMINAR	L	T	P
		0	0	2

COURSE OBJECTIVES

- To work on a technical topics related to process control and Instrumentation Engineering and acquire the ability of written and oral presentation.
- To acquire the ability of writing technical papers for Conferences and Journals.

The students will work for two periods per week guided by student counsellor. They will be asked to present a seminar of not less than fifteen minutes and not more than thirty minutes on any technical topic of student’s choice related to their specialization in Process Control and Instrumentation Engineering and to engage in discussion with audience. They will defend their presentation. A brief copy of their presentation also should be submitted. Evaluation will be done by the student counselor based on the technical presentation and the report and also on the interaction shown during the seminar.

COURSE OUTCOMES

1. The students will be getting the training to face the audience and to interact with the audience with confidence.
2. To tackle any problem during group discussion in the corporate interviews.

PCIT 303	THESIS PHASE – I	L	T	P
		0	0	15

COURSE OBJECTIVES

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE OUTCOMES

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

1. Take up any challenging practical problems and find solution
2. Learn to adopt systematic and step-by-step problem solving methodology

Mapping with Programme Outcomes					
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			✓
CO2		✓		✓	

PCII 304	INDUSTRIAL TRAINING	L	T	P
		0	0	2

COURSEOBJECTIVES

- To train the students in the field work related to process control and instrumentation and to have a practical knowledge in carrying out process control and instrumentation field related works.
- To train and develop skills in solving problems during execution of certain works related to process control and instrumentation.

The students individually undergo a training program in reputed concerns in the field of Process Control and Instrumentation during the summer vacation (at the end of second semester for full – time / fourth semester for part – time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training they had, within ten days from the commencement of the third semester for Full-time / fifth semester for part-time. The students will be evaluated by a team of staff members nominated by head of the department through a viva-voce examination.

COURSE OUTCOMES

1. The students can face the challenges in the practice with confidence.
2. The student will be benefited by the training with managing the situation arises during the execution of works related to Process Control and Instrumentation.

PCIT 401	THESIS PHASE – II	L	T	P
		0	0	15

COURSE OBJECTIVES

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE OUTCOMES

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

1. Take up any challenging practical problems and find solution.
2. Learn to adopt systematic and step-by-step problem solving methodology.

Mapping with Programme Outcomes					
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			✓
CO2		✓		✓	

PROFESSIONAL ELECTIVE COURSES

PCIE X0X	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P
		4	0	0

COURSE OBJECTIVES

- To review the mathematical basis of discrete time signal analysis.
- To discuss the estimation theory and predictors.
- To design and implement adaptive filters.
- To study the techniques of modern signal processing applications using multirate transforms.

Discrete Random Signal Processing: Discrete Random Processes, Expectations, variance, Co-variance, scalar product, energy of discrete signals- Parseval's theorem. Wiener Khintchine relation- power spectral density Periodogram sample autocorrelation-sum decomposition theorem, spectral factorization theorem- discrete random signal processing by linear systems-simulations of white noise-low pass filtering of white noise.

Spectrum Estimation: Non-parametric methods-correlation method --co-variance estimator -performance analysis of estimators-unbiased, consistent estimators Periodogram Estimator-Barlett spectrum estimation-Welch estimation Model based approach- ARMA, ARMA Signal Modeling -Parameter estimation using Yule - Walker method.

Linear Estimation And Prediction: Maximum likelihood criterion- efficiency of estimator - least mean squared error criterion-wiener filter discrete wiener Hoff equations-Recursive estimators - Kalman filter- linear prediction, prediction error- whitening filter, inverse filter-Levin son recursion, Lattice recursion, Lattice realization and Levinson recursion algorithm for solving Toeplitz system of equations.

Adaptive Filters: FIR adaptive filters - Newton's steepest decent method - adaptive filter based on steepest descent method Window-Hoff LMS adaptive algorithm - Adaptive channel equalization- Adaptive echo chancellor- adaptive noise cancellation- RLS adaptive filters-Exponentially weighted RLS- sliding window RLS-simplified IIR LMS adaptive filter.

Multirate and Wavelet Transform: Review of Decimation and Interpolation Process. Sub band filter theory – PR condition – Cosine modulated filters – Para-unitary filters. Application of wavelet transform with Sub band filter theory. Wavelet transform as a correlator. Multiresolution theory – Heisenberg uncertainty principle – Two dimensional wavelet transform.

REFERENCES

1. Manson H.Hayes, Statistical Digital Signal Processing and Modelling, John Wiley and sons, Inc., New York, 1996.
2. John G. Proakis, Dimitris G. Manolakis, Digital Signal processing, prentice Hall of India, 1995.
3. Sopocles J. Orfanidis, Optimum Signal Processing, McGraw Hill, 1990.

4. N. J Fliege , Multirate Digital Signal Processing, John Wiley & Sons, 1999.
5. Soman K P, Ramachandran K I, Insight into Wavelets: From Theory To Practice, Prentice Hall of India, 2004.

COURSE OUTCOMES

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

1. Analysethe functions and characteristics of different op-amps.
2. Familiarize with various estimation techniques.
3. Able to realize systems using different realization algorithms.
4. Able to analyze and implement different types of adaptive filters.
5. Familiarize with multirate wavelet transform and its implementation.

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓			
CO2	✓	✓			
CO3	✓		✓		
CO4		✓		✓	✓
CO5			✓		✓

		L	T	P
PCIE X0X	**EMBEDDED SYSTEMS**	**4**	**0**	**0**

COURSE OBJECTIVES

- To impart knowledge on the embedded controllers and embedded software development process.
- To understand the concepts of real time operating systems.

Embedded Controllers: 8051 and PIC 16F877 :Architecture - Memory Organization - Addressing Modes– Instruction sets – Simple programs.

Embedded Peripherals and Networking: Embedded peripherals in 8051 & PIC16F877 :Timer – Counter - UART/USART – Interrupts– I/O devices : LED – LCD – Keyboard - Embedded Networking : RS485 -I^2C – SPI – USB – CAN– LIN – Wireless LAN – IEEE 802.11 – Bluetooth.

Advanced Embedded Controller:ARM and its Derivatives - Architecture – Modes of operation – Instruction set –Peripheral interfacing – Applications.

Embedded System Software Development: Integrated Development Environment : Software IDEs for 8-bit controller : RIDE – CCS - Software IDEs for 32-bit controller : GNU 'C' – Keil –

Embedded Software Tools : Assembler – Compiler – Linker – Simulator – Debugger – In-circuit Emulator.

RTOS Based Embedded System Design: Basic concepts of RTOS – Tasks, Processes and Threads – Multiprocessing and Multitasking – Task Scheduling – Task Communication – Task Synchronisation – Device Drivers – Interrupt Processing – Memory Management – Message Queues - Comparison and study of various RTOS such as Windows CE, Embedded Linux, µcos, QNX, VXWORKS and Nucleus.

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1. Muhammad Ali Mazidi and Janice GillispieMazidi, 'The 8051 Microcontroller and Embedded Systems' Pearson Education, Second Edition, 1999.
2. Muhammad Ali Mazidi, RolinD.Mckinlay and Danny Causey,'PIC Microcontroller and embedded system',Pearson International Edition, 2008.
3. ARM Architecture Reference Manual, ARM Ltd.,2005.
4. Shibu K.V, 'Introduction to Embedded Systems', Tata McGraw Hill Education private Ltd., 2009.
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6. Rajkamal, 'Embedded system Architecture, Programming and Design', Tata McGraw Hill Education private Ltd.,2008.
7. Kenneth J. Ayala, ' The 8051 Microcontroller Architecture, Programming &Applications',West Publishing Company, Third Edition, 1991.
8. MykePredko , 'Programming & Customizing PIC Microcontrollers',Tabelectronics,Third Edition,1997.
9. David Seal, 'ARM Architecture Reference Manual', Pearson Education, Second Edition,2001.

COURSE OUTCOMES

1. Will gain knowledge on the embedded controllers and embedded peripherals.
2. Ability to select embedded hardware components & its interface
3. Gain knowledge on embedded software development process
4. Will be able to know the basics of real time operating systems.

	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓		✓
CO2			✓		✓
CO3		✓			✓
CO4		✓		✓	✓

PCIE X0X	MACHINE LEARNING TECHNIQUES	L	T	P
		4	0	0

COURSE OBJECTIVES

- To understand the machine learning theory.
- To train linear and non-linear learning models.
- To build tree and ensemble based models.
- To implement clustering & dimensionality reduction techniques.
- To apply reinforcement learning techniques.

Foundations of Learning:
Components of learning – learning models – geometric models – probabilistic models – logicmodels – grouping and grading – learning versus design – types of learning – supervised – unsupervised – reinforcement – theory of learning – feasibility of learning – error and noise – training versus testing – theory of generalization – generalization bound – approximationgeneralizationtradeoff – bias and variance – learning curve - Nearest neighbor models.

Linear Models:
Univariate linear regression – multivariate linear regression – generalization and overfitting– validation–regularizedregression – going beyond linearity– locally weighted regression - Logistic regression – perceptrons – multilayer neural networks – learning neuralnetworks structures – support vector machines – soft margin SVM.

Tree and Ensemble Models
Decision trees – learning decision trees – pruning – ranking and probability estimation trees– regressiontrees – k-d trees–ensemble learning– bagging and random forests – boosting – meta learning.

Unsupervised Learning
K-means – clustering around medoids – silhouttes – hierarchicalclustering– Mixture of Gaussians – EM algorithm - principal component analysis –locality sensitive hashing – partial least squares –chemometrics applications.

Reinforcement Learning
Passive reinforcement learning – direct utility estimation – adaptive dynamic programming – temporal-difference learning – active reinforcement learning – exploration – learning an actionutilityfunction – Generalization in reinforcement learning – policy search – applications in gameplaying – applications in robot control.

REFERENCES

1. C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2007.
2. T. M. Mitchell, “Machine Learning”, McGraw Hill, 1997.
3. Y. S. Abu-Mostafa, M. Magdon-Ismail, and H.-T. Lin, “Learning from Data”, AMLBook

Publishers, 2012.
4. R. G. Brereton, “Applied Chemometrics for Scientists”, John Wiley & Sons, Ltd., 2007.
5. Stanfod CS229 Course: http://cs229.stanford.edu
6.Stanfod CS229 Course:https://www.youtube.com/playlist?list=PLA89DCFA6ADACE599
7. P. Flach, “Machine Learning: The art and science of algorithms that make sense of data”, Cambridge University Press, 2012.
8. K. P. Murphy, “Machine Learning: A probabilistic perspective”, MIT Press, 2012.
9. M. Mohri, A. Rostamizadeh, and A. Talwalkar, “Foundations of Machine Learning”, MIT Press, 2012.

COURSE OUTCOMES

1. Ability to understand the basic theory underlying machine learning.
2. Will be able to understand a range of machine learning algorithms along with their strengths and weaknesses.
3. Will be able to formulate machine learning problems corresponding to different applications.
4. Will be able to apply machine learning algorithms to solve problems of moderate complexity.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓	✓		
CO2	✓	✓	✓		
CO3			✓	✓	✓
CO4				✓	✓

PCIE X0X	**OPTIMAL CONTROL**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To study about the statement of optimal control problem, formulation of optimal control problem and selection of performance measure.
- To understand the concepts of fundamental concepts of calculus of variation and variational approach to optimal control problems.
- To derive the expression for continuous and discrete linear optimal regulator problem.
- To study about the concepts of dynamic programming and its application.
- To understand the concept of numerical solution of two point boundary value problem.

Optimal Control Problems and Performance Measures

Statement of optimal control problem - problem formulation and forms of optimal control - selection of performance measures.

Calculus of Variation

Fundamental concepts – extremumfunctionals involving single and several independent functions - Final time and final state are fixed - Final time is fixed and final state is free - Final time is free and final state is fixed - Both final time and final state are free. Piecewise smooth extremals - constrained extrema.

Variational Approach to Optimal Problems

Necessary conditions for optimal control - Pontriyagin's minimum principle - state inequality constraints - minimum time problem - minimum control effort problems.

LQ Control Problem

Linear optimal regulator problem - Matrix Riccati equation and solution method - choice of weighting matrices - steady state properties of optimal regulators - linear tracking problem.

Dynamic Programming

Principle of optimality - recurrence relation of dynamic programming for optimal control problem - computational procedure for solving optimal control problems - dynamic programming application to discrete systems - Hamilton Jacobi Bellman equation. Numerical Techniques: Numerical solution of two-point boundary value problem - Steepest decent and Fletcher Powell methods.

REFERENCES

1. D.E.Kirk, Optimal Control Theory-An Introduction, Dover Publications, New York, 2012.
2. M.Gopal, Modern Control Systems Theory, Third Edition, New Age International Publishers, 2015.
3. Katruhiko Ogata, Modern Control Engineering, Prentice Hall of India Ltd, Fifth Edition, 2010.
4. Michael Athans and Peter L. Falb, Optimal Control: An Introduction to the Theory and Its Applications, Dover Publications, New York, 2007.
5. Sage A.P. and White C.C, Optimum System Control, Prentice Hall, New Jersey, 1977.

COURSE OUTCOMES

After completion of this paper the student will have

1. Ability to understand the optimal control problem formulation and its selection of performance measures.
2. Ability to recognize and recall the fundamentals of calculus of variation.
3. Ability to implement optimal control concept for minimum time and minimum control effort problems.

4. Ability to apply Matrix Ricatti Equation for real world problem.
5. Ability to understand the concepts of dynamic programming and to find numerical solution of two-point boundary value problem.

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	
CO2	✓		✓	✓	
CO3	✓				
CO4	✓		✓		
CO5	✓				✓

PCIE X0X	ADVANCED INSTRUMENTATION SYSTEMS	L	T	P
		4	0	0

COURSE OBJECTIVES

1. To familiarize the students with concepts of fiber optic sensors, modulating techniques and measurement methods.
2. To impart knowledge about laser instrumentation and its application in industry.
3. To equip the students the principle and application of ultrasonic instrumentation systems.
4. To learn about virtual instrumentation including loops, arrays and file I/O.
5. To understand about the smart instruments used in transmitters,communication and measurement systems.

Fiber Optic Instrumentation

Principle of light propagation through a Fiber- Different types of fiber and their properties-Fiber optic sensors- fiber optic instrumentation systems- Different types of modulators- Optical Detectors- Measurement of length by Interferometer method- Moiré fringes- Measurement of pressure, temperature, current, voltage, liquid level and strain.

Laser Instrumentation

Fundamental characteristics of Laser-Three level and four level laser-Laser modes- resonator configuration-Q switching and mode locking-cavity dumping-Types of laser- Measurement of length, distance, velocity, acceleration, current, voltage and atmospheric effects using Laser-material processing- laser heating, welding, melting and trimming of materials- Removal and vaporization.

Ultrasonic Instrumentation

Principle and propagation of Ultrasonic waves- Characterization of ultrasonic transmission-Reflection and transmission coefficients-Generation of ultrasonic waves-Magnetostrictive and piezoelectric effects- Ultrasonic test methods-pulse echo, transit time, resonance, direct contact and immersion type-Measurement of thickness, depth, flow using ultrasonic sensors.

Virtual Instrumentation

Block diagram and architecture of virtual instrumentation- VI's and sub VI's- Loops and charts- Arrays, Clusters and Graphs-Case and sequence structures-Formula nodes, local and global variables- String and file I/O- Instrument drivers- Publishing data in the web.-Simulation of system using VI- Development of virtual instrument using GUI.

Smart Measuring Instruments

Smart/Intelligent transducer- Comparison with conventional transducers- Self diagnosis and remote calibration features- Smart transmitter with HART communicator protocol -Measurement of temperature, pressure and Flow using HART transmitter.

REFERENCES

1. Govind P. Agrawal, Fiber-Optic Communication Systems, 4th Edition, Wiley publication, 2010.
2. S.Nagabhushana and N.Sathyanarayana, Lasers and Optical Instrumentation, I.K.International publishing, 2010.
3. John F.Ready," Industrial Applications of Laser", Academic press, 1997.
4. Gary Johnson, "LabVIEW Graphical Programming", McGraw Hill, 2006.
5. Jovitha Jerome, Virtual Instrumentation using LabVIEW, , Eastern Economy edition, PHI learning private Ltd., 2010
6. Lisa .K, Wells and Jeffrey Travis, "LABVIEW for Everyone", Prentice Hall, 2009.
7. Paul. W.Chapman, "Smart sensors" ISA Publications, 1996.
8. J.B.Dixit, AmitYadav, "Intelligent Instrumentation for Engineers", University Science Press 2012.

COURSE OUTCOMES

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

1. Select fiber optic sensors and Design a fiber optic based instrumentation system for the measurement of industrial process variables.
2. Apply the principle of Lasers and develop laser based measuring instrumentation system.
3. Develop ultrasonic instrumentation system for measurement and analysis.
4. To design systems applying virtual instrumentation principles.
5. Handle smart instruments and HART transmitters.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓	✓		
CO2	✓		✓		
CO3			✓		
CO4	✓		✓	✓	
CO5			✓		✓

PCIE X0X	ADAPTIVE CONTROL	L	T	P
		4	0	0

COURSE OBJECTIVES

- To impart knowledge on how to recursively estimate the parameters of discrete input – output models (ARX/ARMAX etc) using recursive parameter estimation methods.
- To make the student understand the principles of STR, MRAC and Gain scheduling.
- To craft the student design simple adaptive controllers for linear systems using above methods.

Introduction

Introduction to System Identification: – Adaptive Control Vs Conventional feedback control - adaptive control schemes.

Gain schedulingand Model Reference Adaptive System

The principle - Design of gain scheduling controllers- Nonlinear transformations - application of gain scheduling - Auto-tuning techniques: Methods based on Relay feedback- Introduction to self oscillating adaptive system. Introduction- MIT rule – Determination of adaptation gain - Lyapunov theory –Design of MRAS using Lyapunov theory – Bounded input bounded output stability – output feedback – Relations between MRAS and STR– Non-Linear systems.

Deterministic self-tuning regulators

Pole Placement design - Indirect Self-tuning regulators - direct self-tuning regulators – Disturbances with known characteristics. Direct adaptive control: Introduction – Adaptive tracking and regulation with independent objectives – Basic design – Extensions of the design – Adaptive tracking and regulation with weighted input – Adaptive minimum variance tracking and regulation – The Basic Algorithms – Asymptotic convergence analysis – Martingale convergence analysis – Adaptive generalized minimum variance control.

Stochastic self-tuning regulators

Design of minimum variance controller - Design of moving average controller - stochastic self-tuning regulators. Indirect adaptive control: Introduction – Adaptive pole placement – The basic algorithm – Analysis of the indirect adaptive pole placement – The "Singularity" problem – Adding external excitation –Adaptive generalized predictive control – Adaptive linear quadratic control – Iterative identification in closed loop and controller redesign.

Robust Self-Tuning Regulators,Practical aspectsand **Case studies**

Robust direct adaptive control – The problem – Direct adaptive control with bounded disturbances – Direct adaptive control with un modelled dynamics – An example.Robust indirect adaptive control - Standard robust adaptive pole placement – Modified robust adaptive pole placement-Practical aspects of Adaptive Control system.

Temperature control in a distillation column, chemical reactor control, pulp dryer control & control of a rolling mill.

REFERENCES

1. I.D.Landau, R.Lozano and M.M'Saad, Adaptive Control, Springer – Verlog London limited, 1998.
2. Karl J.Astron Bjorn Wittenmark, Adaptive Control, second edition, Pearson Education pvt limited, 2005**.**
3. K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Second Edition, Pearson Education Inc., 1995.
4. T. Soderstorm and PetreStoica, “System Identification”, Prentice Hall International(UK) Ltd., 1989.
5. N.Mathivanan, ”PC-based Instrumentation Concepts and Practice”, Eastern Economy Edition, PHI Learning private ltd ,2009.
6. LennartLjung, “System Identification: Theory for the User”, Second Edition, Prentice Hall, 1999.

COURSE OUTCOMES

1. Will be able to design simple adaptive controllers for linear systems.
2. Ability to identify, formulate analyse the adaptive controllers.
3. Ability to implementadaptive controllers to engineering problems.

	PO1	PO2	PO3	PO4	PO5
CO1		✓	✓		✓
CO2			✓		✓
CO3			✓		✓

PCIE X0X	FAULT TOLERANT CONTROL	L	T	P
		4	0	0

COURSE OBJECTIVES

- To understand different faults that occurs in sensors and actuators.
- To identify kind, size and magnitude of the fault by model based and model free methods.
- To understand the structured residuals and directional structured residuals.
- To understand the methods to estimates the faults.

Introduction to Fault Detection and Diagnosis (FDD)

Scope of FDD: Types of faults and different tasks of Fault Diagnosis and Implementation - Different approaches to FDD: Model free and Model based approaches. Classification of Fault and Disturbances - Different issues involved in FDD Typical applications.

Analytical Redundancy Concepts

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.

Design of Structured Residuals

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.

Design of Directional Structured Residuals

Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation- Introduction of Residual generation of parametric fault – Robustness Issues- Statistical Testing of Residual generators

Data Driven Methods

Principal Component Analysis – Partial Least Squares - Canonical Variate Analysis – Knowledge Based Methods.

REFERENCES

1. Janos J. Gertler, Fault Detection and Diagnosis in Engineering systems, Second Edition, Marcel Dekker, 1998.
2. R. Isermann, Fault-Diagnosis Systems An Introduction from Fault Detection to Fault Tolerance, Springer Verlag, 2006.
3. L.H. Chiang, E.L. Russell and R.D. Braatz, Fault Detection and Diagnosis in Industrial Systems – Springer-Verlag-London, 2001.
4. Rami S. Mangoubi, Robust Estimation and Failure detection, Springer-Verlag London 1998.

COURSE OUTCOMES

1. Ability to Understand different approaches to Fault Detection and Diagnosis
2. Ability to Estimate the kind, size, type and time of occurrence of faults by analytical methods.
3. Ability to design and detect single and multiple faults using structured residual approach
4. Ability to design and detect single and multiple faults using directional structured residual approach
5. Ability to Understand the data driven methods like PCA, partial least square methods.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2	✓	✓		✓	✓
CO3			✓	✓	
CO4			✓	✓	
CO5		✓			

PCIE X0X	STATISTICAL PROCESS CONTROL	L	T	P
		4	0	0

COU

RSE OBJECTIVES

- To make the students understand the purpose and uses of SPC.
- To use the most common types of control charts and carry out process capability studies.
- To import knowledge about various SPC tools, data collection and construct basic control charts.
- To make the students understand concept of control charts for variables and attributes and how to interpret control chart results.
- To impart knowledge of other statistical process monitoring and control techniques.

Quality Improvement In The Modern Business Environment

The Meaning of Quality and Quality Improvement, Dimensions of Quality, Quality Engineering Terminology, A Brief History of Quality Control and Improvement, Statistical Methods for Quality Control and Improvement, univariate process monitoring and control.

Methods And Philosophy Of Statistical Process Control

Introduction, Chance and Assignable Causes of Quality Variation, Statistical Basis of the Control Chart Basic Principles, Choice of Control Limits, Sample Size and Sampling Frequency, Rational Subgroups Analysis of Patterns on Control Charts, Discussion of Sensitizing Rules for Control Charts, Control Charts Application, The Rest of the Magnificent Seven, Implementing SPC in a Quality Improvement Program, An Application of SPC, Applications of Statistical Process Control and Quality Improvement Tools in Transactional and Service Businesses.

Control Charts for Variables

Control Charts for X and R, Statistical Basis of the Charts, development and Use of X and R Charts, Charts Based on Standard Values, Interpretation of X and R Charts. The Effect of Non normality on X and R Charts, The Operating Characteristic Function, The Average Run Length for the X Chart, Control Charts for –x and s, Construction and operation of X and s charts, The X and s Control Charts with Variable Sample size, Summary of Procedures for X and R, and s Charts, Applications of Variables Control Charts.

Control Charts For Attributes

The Control Chart for Fraction Nonconforming, Development and Operation of the Control Chart Variable Sample Size, Applications in Transactional and Service Business, The Operating Characteristic Function and Average Run Calculations, Control Charts for Nonconformities (Defects).

Other Statistical Process Monitoring And Control Technique

The Cumulative Sum Control Chart, Basic Principles: The CUSUM Control Chart for Monitoring the Process Mean, The Tabular or Algorithmic Cusum for Monitoring the Process Mean, Recommendations for Cusum Design, Exponential weighted moving average [EWMA],

EWMA for Monitoring the Process Mean, design of EWMA, combining EPC[Engineering process control] and SPC, MINITAB software.

REFERENCES

1. Donald J. Wheeler, "Understanding Variation: The Key to Managing Chaos 2", SPC Press, Revised Edition, 2000.
2. Paul Keller, "Statistical Process Control Demystified", McGraw Hill Education, 1st Edition,2011.
3. Douglas Montgomery, "Introduction to Statistical Process Control", Wiley publications, 7th Edition, 2013.
4. eslie M. Licinski, "Statistical process control" , Artech House Publication,2000.
5. PeihuaQiu, "Introduction to Statistical Process Control" CRC Press, second Edition, 2013.
6. John S. Oakland, "Statistical process control", Butterworth Heinmann, sixth edition, 2008.

COURSE OUTCOMES

1. Able to analyse quality control in industries.
2. Able to understand SPC and its design tools.
3. Ability to construct control charts.
4. Able to understand the concept of variable and attribute charts.
5. Able to understand process monitoring and control techniques.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓	✓		
CO2	✓			✓	
CO3		✓			
CO4	✓				
CO5	✓		✓		✓

PCIE X0X	**MEMS DESIGN AND FABRICATION**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To introduce the basic concepts of micro systems and advantages of miniaturization.
- To teach the fundamentals of micromachining and micro fabrication techniques.
- To train the students on the design of micro sensors and actuators and fabrication flow process.

- To impart knowledge on various packaging technologies for MEMS.

Introduction to micro machined devices: Miniaturization-Microsystem verses MEMS– Micro fabrication– Smart Materials, Structures and System– Integrated Microsystem Micromechanical Structure, Micro sensors, Micro actuator – Introduction to Scaling – Scaling in Geometry– Scaling in Rigid– body dynamics: Scaling in Dynamic Forces – the Trimmer Force Scaling Vector – Scaling in electrostatic forces – scaling in electricity.Modeling of solids in microsystem:The Simplest Deformable Element: A Bar- Transversely Deformable Element: A Beam –Energy Methods for Elastic Bodies – Examples and Problems–Concepts of spring constant and Estimation of spring constant for simple cantilever beam, fixed-fixed beam microstructures– In-Plane Stresses.

Micromachining technologies: Silicon as a Material for Micromachining: Crystal Structure of Silicon–Silicon Wafer Preparation– Thin Film Deposition: Evaporation–Sputtering–Chemical Vapour Deposition–Epitaxial Growth of Silicon– Thermal Oxidation for Silicon Dioxide– Lithography: Photolithography – Lift-Off Technique – Etching: Isotropic Etching–Anisotropic Etching–Etch Stops–Dry Etching–Silicon Micromachining – Specialized Materials for Microsystem: Polymers–Ceramic Materials– Advanced Processes for Micro Fabrication–Wafer Bonding Techniques–Special Micro Fabrication Techniques.

Micro Sensors: Concepts of Piezoresistivityand Piezoelectricity– Fabrication Processes, Principle of Operation and Design of Silicon Piezo Resistive Accelerometer, Capacitive Accelerometer, Folded Beam Comb Drive Capacitive Accelerometer,Piezo Electric Accelerometer – Fabrication Processes, Principle of Operation and Design of Silicon Capacitive Pressure Sensor, Silicon Piezo Resistive Pressure Sensor, Piezo Electric Pressure Sensor – Overload Protection in Pressure Sensors– Principle of operations and Fabrication Process of Conductometric Gas Sensors, Portable Blood Analyzers and Piezoelectric Ink Jet Printers.

MEMS Actuators and their applications: Actuation mechanisms – Electrostatic actuation – Electrostatic cantilever actuators – Torsional electrostatic actuators – Electrostatic comb drives – Feedback stabilization of electrostatic actuators –Electrostatic rotary micro motors – Electrostatic linear micro motors – Electrostatic micro grippers – Electrostatic relays and switches – Thermal actuation – Thermal expansion of solids – Thermal array actuators –Piezoelectric actuation – Cantilever resonators. RF MEMS switches – Pull in and Pull out voltage analysis.

Integration of micro and smart systems: CMOS FirstApproach -MEMS FirstApproach –Other Approaches of integration– Microsystem Packaging: Objectives of Packaging, Special Issues in Microsystem Packaging, types of microsystem packages, Packaging Technologies, Reliability and key Failure Mechanisms – Case studies of integrated microsystems: Pressure sensor, Micro machined Accelerometer.

REFERENCES

1. 1.G.K.Ananthasuresh,K.JVinoy, S.Gopalakrishnan, K.N.Bhat, V.K.Aatre, Micro and Smart Systems, Wiley India, First Edition,2010.

2. 2.Tai-Ran-Hsu, MEMS & Microsystems Design and Manufacture, TATA McGraw-Hill, New Delhi, 2002.
3. 3.Chang Liu, Foundations of MEMS, (ILLINOIS ECE Series), Pearson Education International, 2006.
4. 4.Stephen D. Senturia, Micro system Design, Springer International Edition, 2001.
5. 5.Gregory TA Kovacs, Micro machined Transducers Source Book, WCB McGraw Hill, Singapore, 1998.

COURSE OUTCOMES

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

1. Know the basic concepts of micro systems and advantages of miniaturization.
2. Understand the fundamentals of micromachining and micro fabrication techniques.
3. Expertise the knowledge in design of micro sensors and actuators fabrication.
4. Develop various packaging techniques in the design of MEMS.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓				
CO2	✓				
CO3		✓	✓	✓	
CO4	✓		✓		✓

PCIE X0X	**AUTOMOTIVE INSTRUMENTATION**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To make the students to understandthe role of electronics and software related to current trends in automobiles.
- To provide fundamental knowledge of sensors and other technologies used in modern automobiles.
- To provide a strong knowledge on control system to improve safety measures and also to increase comforts of users.
- To impart knowledge on Automotive standards and protocols.

Introduction of automobile system

Current trends in automobiles with emphasis on increasing role of electronics and software, overview of generic automotive control ECU functioning, overview of typical automotive subsystems and components, AUTOSAR.

Engine management systems
Basic sensor arrangement, types of sensors such as oxygen sensors, crank angle position sensors, Fuel metering/ vehicle speed sensors, flow sensor, temperature, air mass flow sensors, throttle position sensor, solenoids etc., algorithms for engine control including open loop and closed loop control system, electronic ignition, EGR for exhaust emission control.

Vehicle power train and motion control
Electronic transmission control, adaptive power Steering, adaptive cruise control, safety and comfort systems, anti-lock braking, traction control and electronic stability, active suspension control.

Active and passive safety system
Body electronics including lighting control, remote keyless entry, immobilizers etc., electronic instrument clusters and dashboard electronics, aspects of hardware design for automotive including electro-magnetic interference suppression, electromagnetic compatibility etc., (ABS) antilock braking system, (ESP) electronic stability.

Automotive standards, protocolsand energy management
Automotive standards like CAN protocol, LIN protocol, flex ray, OBD-II, CAN FD, automotive Ethernet etc. Automotive standards like MISRA, functional safety standards (ISO 26262).
BMS (battery management system), FCM (fuel control module),principles of system design, assembly process of automotives and instrumentation systems.

REFERENCES

1. Understanding Automotive Electronics by William B. Ribbens, Butterworth Heinemann Woburn, 6th ed., 2003.
2. Sensors Applications, Sensors for Automotive Technology by Jiri Marek, Hans Peter Trah, Wiley, 1st Edition.
3. U.Kiencke, and L. Nielson, *Automotive Control Systems*, Springer Verlag Berlin, 2000.
4. Automotive Electrical Equipment by Young A.P., Griffiths, ELBS & New Press, 1999.
5. Automotive computers and control system by Tom Weather Jr. &Cland C. Hunter, Prentice Hall Inc., New Jersey.
6. Automobile Electrical Equipment by Crouse W.H., McGraw Hill Co. Inc., New York, 1995.
7. Understanding Automotive Electronic by Bechhold, SAE, 1998.
8. Automotive Hand Book by Robert Boshe, Bentely Publishers, 5th ed. Germany, 2005.

COURSE OUTCOMES
After learning this course, the students should be able to:
1. Evaluate the sensor and measuring system of automobile.
2. Design the basic modeling and control scheme for automotive systems.
3. Acquire knowledge of various automotive standards and Protocols.

	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓		✓
CO2	✓			✓	
CO3			✓		✓

OPEN ELECTIVE COURSES

PCIE X0X	INDUSTRIAL DRIVES AND CONTROL	L	T	P
		4	0	0

COURSE OBJECTIVES

- To learn about electric drives & its types.
- To acquire knowledge about the circuit model of electric motors.
- To implement the power converters for the drives by efficient control algorithms.
- To understand the need for the digital controllers.
- To study about the generation of control pulses for power electronic converters.

and their applications.

Introduction to electric drives: Classification, characteristics and advantages of electric drives – Speed- torque characteristics of various types of loads and drive motors – Joint speed- torque characteristics - Selection of power rating for drive motor based on thermal limits – Overload capacity – Starting, braking and reversing methods for various types of motors.

Modeling of DC and AC machines: Circuit model of Electric Machines – Transfer function and State space models of series and separately excited DC motor - AC Machines – Dynamic modeling – linear transformations – equations in stator, rotor and synchronously rotating reference frames – flux linkage equations – Dynamic state space model- modeling of Synchronous motor.

Control of DC drives: Analysis of series and separately excited DC motor with single phase converters operating in different modes and configurations – Analysis of series and separately excited DC motor fed from different choppers – two quadrant and four quadrant operation – Closed loop control of dc drives – Design and analysis of controllers for load changes.

Control of AC drives: Induction motor drives – stator voltage control of induction motor – torque – slip characteristics – operation with different types of loads – operation with unbalanced source voltages and single phasing – analysis of induction motor fed from non – sinusoidal voltage supply – stator frequency control – variable frequency operation – V/F control, controlled current and controlled slip operation.Synchronous motor drives – Principles of Synchronous motor control – adjustable frequency operation of synchronous motors – voltage source inverter drive with open loop control static rotor resistance control and slip power recovery scheme.

Digital techniques in speed control: Advantages and limitations – Microprocessor, microcontroller and PLC based control of drives – Selection of drives and Control schemes for paper mills, cement mills, sugar mills.

REFERENCES

1. VedamSubrahmaniam, Electric drives – Concepts and applications, Tata McGraw Hill Publishing House, Chennai, 1994.
2. G.K. Dubey, Fundamental of electrical drives, Narosa Publishing House, Chennai, 1995.
3. J.M.D Murphy & F.G. Turnbull, Power Electronic Control of AC motors, Pergamum Press, New York,1988.
4. G.K.Dubey, “Power Semiconductor Controlled Drives,” Prentice Hall International, New Jersey, 1989.
5. Paul .C.Krause, Oleg wasynczuk and Scott D.Sudhoff, “Analysis of Electric Machinery and Drive Systems”, 2ndedition , Wiley-IEEE Press, 2013.
6. Bimal K Bose, “Modern Power electronics and AC Drives”, Pearson education Asia, 2002.
7. R .Krishnan, “Electrical Motor Drives- Modeling, Analysis and Control”, Prentice Hall of India Pvt Ltd., 2nd Edition, 2003.

COURSE OUTCOMES

1. Get a thorough understanding of motor-load system dynamics and stability, modern drive system objectives and fundamentals of dc and ac motors.
2. Will have the ability to model both dc and ac motors in various conventional methods.
3. Confidently design and analyze both converter and chopper driven dc drives.
4. Will have a thorough understanding of conventional control techniques of AC drives and will have the ability to design and analyze such system.
5. Get a detailed knowledge on advanced high performance control strategies for AC drives and emerging technologies in electric drives.

PCIE X0X	WIRELESS SENSOR NETWORKS	L	T	P
		4	0	0

COURSE OBJECTIVES

- To introduce the technologies and applications for the emerging domain of wirelesssensor networks.
- To impart knowledge on the design and development of the various layers in the WSN protocol stack.

- To elaborate the various issues related to WSN implementations.
- To familiarize the students with the hardware and software platforms used in the design of WSN.

Introduction: Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture – Hardware components, energy consumption of sensor nodes, Network architecture – Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, design principles, Development of wireless sensor networks.

Physical Layer: Wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication , packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, energy usage profile, choice of modulation, power management.

Data Link Layer: MAC protocols –fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols, Link Layer protocols – fundamentals task and requirements ,error control ,framing, link management.

Network Layer: Gossiping and agent-based uni-cast forwarding , Energy-efficient unicast, Broadcast and multicast, geographic routing , mobile nodes, Data –centric and content-based networking – Data –centric routing, Data aggregation, Data-centric storage, Higher layer design issue.

Applications of WSN: WSN Applications - Home Control - Building Automation - Industrial Automation - Medical Applications - Reconfigurable Sensor Networks - Highway Monitoring - Military Applications - Civil and Environmental Engineering Applications - Wildfire Instrumentation - Habitat Monitoring - Nanoscopic Sensor Applications – Case Study: IEEE 802.15.4 LR-WPANs Standard - ZigBee - Target detection and tracking.

REFERENCES

1. Feng Zhao and Leonidas J. Guibas, “Wireless Sensor Networks : An Information Processing Approach”, Elsevier, 2004.
2. Holger Karl and Andreas Willig, “Protocols And Architectures for Wireless Sensor Networks”, John Wiley, 2007.
3. Ivan Stojmenovic, “Handbook of Sensor Networks: Algorithms and Architectures”, Wiley,2005.
4. KazemSohraby, Daniel Minoli and TaiebZnati, “Wireless Sensor Networks: Technology, Protocols and Applications”, John Wiley, 2007.
5. BhaskarKrishnamachari, “Networking Wireless Sensors”, Cambridge University Press, 2011.

COURSE OUTCOMES

1. Ability to analyze WSN with respect to various performance parameters in the protocol stack.
2. Ability to understand MAC algorithms and Network protocols used for specific WSN applications.
3. Design and develop a WSN for a given application.

PCIE X0X	VLSI SYSTEM DESIGN	L	T	P
		4	0	0

COURSE OBJECTIVES

- To provide a fundamental understanding of circuit and physical design of Integrated circuits, and a summary of CMOS processing technology.
- To learn the models for transistors to predict the transfer characteristics CMOS Inverters and to address performance estimation for circuits.
- To learn simulation tools to obtain more accurate predictions as well as to verify the correctness of circuits and logic.
- To understand the combinational circuit design and sequential circuit design including clocking and latching techniques.
- To provide subsystem view of CMOS design such as datapath subsystems, memory subsystems and special purpose systems.

Introduction: MOS transistors - CMOS logic - CMOS fabrication and Layout - VLSI Design flow. MOS Transistor theory: Ideal I-V characteristics - C-V characteristics-Non ideal I-V effects-DC transfer characteristics-switch-level RC delay models. CMOS processing technology: CMOS Technologies - Layout design rules - CMOS process enhancements.

Circuit characterization and performance estimation: Delay estimation-Logical effort and Transistor sizing-Power dissipation-Interconnect-Design margin-Reliability-Scaling. Circuit Simulation: Device models - Device characterization – Circuit characterization - Interconnect Simulation.

Combinational circuit design: Circuit families – Low-power logic design - Comparison of circuit families. Sequential circuit Design: Sequencing static circuits - Circuit design of Latches and FFs - Static sequencing element methodology - Sequencing dynamic circuits - Synchronizers.

Data path subsystems: Addition/ Subtraction – Comparators – Counters - Boolean logical operations – Coding – Shifters – Multiplication - Division. Array subsystems: SRAM – DRAM - Read-only memories – Serial access memories – Content-addressable memories - Programmable Logic Arrays - Array yield, Reliability and self-test. Special purpose subsystems: Analog circuits.

Design methodology and tools: Design methodology-Design flows-CMOS physical design styles. Case study: VLSI design of a FFT processor chip using FPGA. Testing and verification: Introduction- Logic verification -basic digital debugging hints-Manufacturing tests- Design for testability-Boundary scan.

REFERENCES

1. Neil H. E. Weste and David Harris, CMOS VLSI Design- A circuit and systems perspective, Third Edition, Pearson Education, 2008.
2. Wayne Wolf, Modern VLSI Design, Fourth Edition, Prentice Hall India, 2010.
3. Caver Mead, Lynn Conway, Introduction to VLSI Systems, BS Publications, 2008.
4. Neil H. E. Weste, Kamran Eshraghian, and Micheal John Sebastian, Principles of CMOS VLSI Design - A Systems Perspective, Addison Wesley, 2001.
5. Douglas A.puknell, kamranEshraghian, Basic VLSI Design, Third Edition, Prentice Hall India, 2010.
6. Neil H. E. Weste and David Harris, Principles of CMOS VLSI Design, Addison Wesley Fourth Edition, 2010.
7. M. John and S. Smith, Application-Specific Integrated Circuits, Addison-Wesley, 1997.

COURSE OUTCOMES

At the end of the course the students will know

1. The principles required to design and lay out a simple CMOS chip on their own.
2. Models for transistors and simulation techniques to characterize a process and to check performance, power and correctness of circuits and interconnect.
3. A range of datapath subsystems, array subsystems and special purpose analog circuits.
4. A range of design methods that can be used to implement a CMOS system.
5. The issues in CMOS chip testing and the methods for incorporating test considerations into chips from the start of the design.

PCIE X0X	**DIGITAL IMAGE PROCESSING**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To study the basics of image processing and its applications.
- To familiarize with image enhancement and image compression techniques.
- To learn about image restoration techniques and implementation of projection algorithms.

Digital Image Processing: Origin– components - examples of fields that use DIP.

Digital Image Fundamentals: Elements of visual perception, light and the EM spectrum, a simple image formation model, image sampling and quantization, some basic relationships between pixels. Image transforms - Two dimensional orthogonal and unitary transforms - properties of unitary transform.

Image Enhancement: Point operations - contrast stretching - clipping and thresholding - digital negative intensity level slicing - bit extraction. Histogram: modelling - eqalization - modification. Spatial operations: smoothing techniques - magnification and interpolation. Transform operations.

Image Compression and Segmentation: Compression models - elements of information theory - error free compression - run length coding - loss less and lossy predictive coding - image compression standards.Image Segmentation - Detection of discontinuities, point, line and edge detections, gradient operators, Laplacian, edge linking and boundary detection, thresholding, region based segmentation.

Image filtering and restoration: Inverse and weiner filters – filtering using image transforms. Splines and interpolation. Maximum entropy restoration. Bayesian methods. Image analysis-spatial feature extraction - transform features. Edge detection – boundary extraction, shape features image segmentation**.**

Image reconstruction from projections: Radon transform-inverse radon transform back projection operator-convolution back projection- parallel beam geometry-Fan beam geometry. MRI Fourier reconstruction.

REFERENCES

1. Rafael C Gonzalez and Richard E Woods, Digital Image Processing, 2nd Edition, Pearson Education, 2003.
2. Jain Anil K., Fundamentals of Digital Image Processing, Prentice Hall of India, New Delhi, 1995.
3. RosenfieldAzriel and KakAvinash C, Digital Picture Processing, Academic Press Inc., NY,1991.
4. Pratt William K, Digital Image Processing, John Wiley and Sons, 2001.

COURSE OUTCOMES

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

1. Anlysethe basics of image processing.
2. Familiarize with image enhancement techniques.
3. Able to compress an image using various compression techniques.
4. Able to restore an image from its degraded version.
5. Construct projections using transforms.

PCIE X0X	MULTI SENSOR DATA FUSION	L	T	P
		4	0	0

COURSE OBJECTIVES

- To learn the concepts and techniques used in sensor data fusion.
- To understand the role of Mathematical tools used.
- To elaborate the concept of Kalman filter to data fusion problems.
- To impart knowledge on advanced filtering techniques .

Multi sensor data fusion: Introduction, sensors and sensor data, Limitations of single sensor, Use of multiple sensors, Fusion applications. The inference hierarchy: output data, Data fusion model, Architectural concepts and issues, Benefits of data fusion.

Mathematical tools used: Algorithms, Taxonomy of algorithms for multisensor data fusion co-ordinate transformations, rigid body motion, Dependability and Markov chains, Meta – heuristics, Data association, Identity declaration.

Estimation: Kalman filtering, practical aspects of Kalman filtering, Extended Kalman filters, Partical filter, Decision level identify fusion, Knowledge based approaches.

Advanced Filtering: Data information filter, extended information filter, Decentralized and scalable decentralized estimation, Sensor fusion and approximate agreement, Optimal sensor fusion using range trees recursively, Distributed dynamic sensor fusion.

High performance data structures: Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system. Application of multisensor data fusion for mobile robot mapping and Navigation.

REFERENCES

1. David L. Hall, Mathematical techniques in Multisensor data fusion, Artech House, Boston, 2004.
2. R.R. Brooks and S.S.Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998.
3. Mitchell.H.B, Multi-Sensor Data Fusion-An Introduction, Springer-Verlag, 2012.
4. Martin Liggins, II,James Llinas, David L.Hall, Handbook of Multisensor Data Fusion, CRC Press, 2008.
5. Arthur Gelb, Applied Optimal Estimation, M.I.T. Press, 1982.

COURSE OUTCOMES

At the end of the course the candidate will be able to

1. Understand the importance of using data fusion in multi-sensor systems.
2. Understand simple approaches to data fusion for enhancing sensor reliability.
3. Derive and apply the Kalman filter to data fusion problems.
4. Understand the importance of sensor management and data association.

PCIE X0X	BIO SIGNAL PROCESSING	L	T	P
		4	0	0

COURSE OBJECTIVES

- To enable the students to conceive and understand the basics of signal processing.
- To gain knowledge about transforms and filters.
- To familiarize with bio electric signals and their processing.

Bio Signal Recording System: review of bio signal characteristics- Spectral characteristics of bio signals – biosensors – sampling, quantization and encoding – multi-rate systems, compressed sensing and lossless data compression.

Bio Signal Analysis: Time domain analysis of bio signals, statistical analysis of bio signals – HOS, SVD, PCA and ICA, Information – theoretic analysis.

Time and Frequency domain analysis: Fourier spectrum of bio signals, Short time Fourier transform and spectrogram, DCT and its applications for bio signals. Correlation analysis and power spectral estimation of bio signals.

Digital Filters for bio signal applications: Illustration of different types of artifacts and noise – time domain filters – frequency domain filters – notch and comb filters – optimal filtering – adaptive filters – filters for signal decomposition.

Event Detection and Feature Extraction Techniques: Signal segmentation – envelope extraction and analysis – temporal and spectral features – statistical features – information-theoretic features – cross spectral features - waveform complexity.

Overview of Bio Signal Processing: Heart rate variability analysis – ECG wave delineation – ECG beat classification – brain wave classification – event change detection and augmented reality medical systems.

REFERENCES

1. Rangaraj M. Rangayyan , Biomedical Signal Analysis: A Case Study Approach, Wiley India, 2009.
2. Eugene N. Bruce, Biomedical Signal Processing and Signal Modelling, Wiley Interscience, 2000.
3. Wills J. Tompkins, Biomedical Digital Signal Processing, Prentice-Hall Inc., Upper Saddle River NJ, USA, 1999.
4. Cohen A, Biomedical signal processing. Vol-I, Time frequency analysis, CRC Press, UK, 1999.

COURSE OUTCOMES

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

1. Review the characteristics of bio signals.
2. Carry out data reduction and compression processes.
3. Design and analyze bio signals.

4. Process appropriate bio electric signals.
5. Perform Feature Extraction Techniques.