B. Tech. Degree

in

INSTRUMENTATION AND CONTROL ENGINEERING

SYLLABUS FOR

FLEXIBLE CURRICULUM

(For students admitted in the academic year 2022-23)

DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

TAMIL NADU, INDIA.

INSTITUTE VISION

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

INSTITUTE MISSION

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically

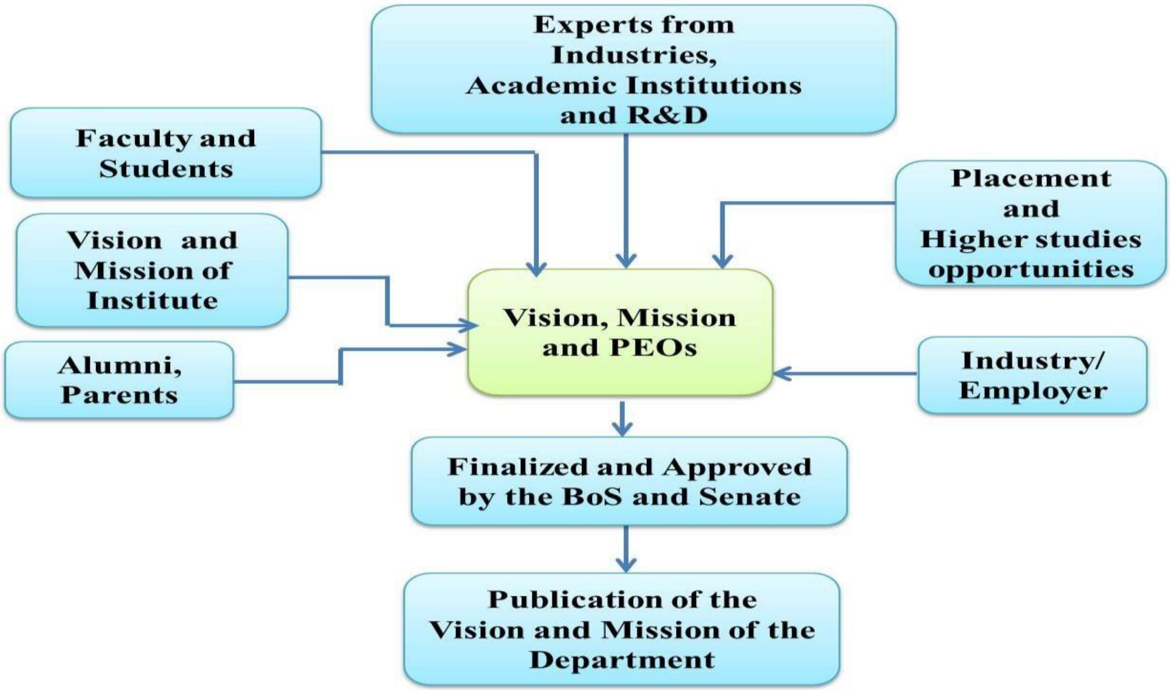
DEPARTMENT VISION

- To be a world class centre of excellence in Instrumentation and Control Engineering.

DEPARTMENT MISSION

- To inspire the students to realize their aspiration and potential through quality education in Instrumentation and Control Engineering.
- To enhance knowledge, create passion for learning, foster innovation and nurture talents towards serving the society and the country.
- To encourage faculty and students to keep in pace with the latest technological developments and to pursue research in those areas.
- To enable the students to engage themselves in entrepreneurship and product development for the benefit of the global community.

PROCESS FOR DEFINING THE VISION AND MISSION OF THE DEPARTMENT, AND PEOs OF THE PROGRAMME



Programme Educational Objectives (PEO)

The major objectives of the 4-year B. Tech. (ICE) programme offered by the department of Instrumentation and Control engineering,

1: to prepare students for core industries/ manufacturing sectors/ IT Enabled Services (ITES)

2: to prepare students for research and development organizations

3: to prepare students for higher studies in engineering and management

4: to prepare students for starting and running enterprises

Program Outcomes (PO)

Graduates of the 4-year B.Tech. Instrumentation and Control Engineering (ICE) programme

1. would have developed an ability to apply the knowledge of mathematics, sciences, and engineering fundamentals to solve complex engineering problems in the field of Instrumentation and Control Engineering,

2. would have possessed a comprehensive understanding of a wider range of electronic devices, analog and digital electronic circuits and the state-of-the-art advanced electronics used in Instrumentation and Control Systems,

3. would have the right knowledge and exposure to a variety of sensors, data acquisition systems, actuators, control methodologies, embedded systems, data structures, algorithms and computer programming, to readily provide innovative design solutions to the engineering problems in industries (e.g. process, power plants, automotive),

4. would have gained adequate knowledge to effectively use simulation software, relevant tools and methodsto analytically investigate problems and interpret data to arrive at valid conclusions,

5. would have learnt necessary skills to develop mathematical models, and deploy appropriate techniquesand IT tools to design advanced control systems and associated instrumentation,

6. would become responsible engineers who understand the socio economical, environmental and legal implications relevant to professional engineering practice,

7. would be able to evaluate and deliver solutions by adopting appropriate sustainable resource management techniques, for optimally utilizing the available resources without endangering the environment,

8. would be competent to apply ethical principles relevant to the professional engineering practices,

9. would be able to function efficiently in various capacities as members, leaders and directors in multi-disciplinary teams to accomplish projects of different magnitudes,

10. would be proficient in languages (spoken and written) in order to listen, understand and communicate effectively to all the stakeholders and society and, make comprehensive reports and presentations on complex engineering activities on a global scale,

11. would be able to evaluate and complete the projects by effective utilization of resources within the stipulated time frame and budget in multi-disciplinary environments,

12. would be able to recognize the need for engaging themselves independently in life-long learning of technological changes.

Programme Specific Outcomes (PSO)

Graduates of the 4-year B.Tech. Instrumentation and Control Engineering (ICE) programme

PSO1: would apply the basic knowledge of Mathematics, Computing and Sciences to develop mathematical models and, apply appropriate techniques and IT tools to identify, formulate and solve real life problems faced in industries and R and D

PSO2: would apply standard practices and combine the emerging technologies into the core area ofICE in the design and investigation of systems for sustainable development

PSO3: would commit themselves to the highest ethical standards and create and maintain professionalism in the work culture and outcome

Curriculum Framework and Credit System for the Four-Year B.Tech. Programme in Instrumentation and Control Engineering

Table 1: Course Structure

Course Category	Courses	No. of Credits	Weightage (%)
General Institute Requirement (IR) Courses	22	50	31.85
Programme Core (PC)	15	49*	31.21
Programme Electives (PE)/ Open Electives (OE)	14$	42	26.75
Essential Laboratory Requirements (LR)	8 (Maximum 2 per semester up to 6th semester)	16	10.19
Total	59	**157**	**100**
Minor (Optional)	5	15 (Additional credits)	-
Honours (Optional)	4	15 (Additional credits)	-

* 4 programme core courses shall be 4 credits each
$ Out of 14 elective courses (PE/OE), the students should study at least eight programme elective courses (PE)

Table 2: IR Courses

Sl. No.	Name of the course	Number of courses	Max. Credits
1., 2., 3.	Mathematics - I, II, III in semesters I, II, III	3	10
4.	Physics	1	3
5.	Physics Lab	1	2
6.	Chemistry	1	3
7.	Chemistry Lab	1	2
8.	Industrial Economics and Foreign Trade	1	3
9., 10.	English for Communication- Theory **AND** Lab	2	4
11.	Energy and Environmental Engineering	1	2
12.	Professional Ethics	1	3
13.	Engineering Graphics	1	3
14.	Engineering Practice	1	2
15., 16.	Basic Engineering- Civil Engg. **AND** Mechanical Engg.	2	4
17.	Introduction to Computer Programming	1	3
18.	Branch Specific Course (Introduction to the Branch of study)	1	2
19.	Summer Internship	1	2
20.	Comprehensive viva	1	1
21.	Industrial Lecture	1	1
22.	NSS/NCC/NSO	1	Compulsory Participation Pass/Fail
	Project work#	1#	6#
	Total	**22**	**50**

Optional

B 9.0 Internship/Industrial Training

Students should undergo industrial training/internship for a minimum period of six weeks during the summer vacations. Registration for this course shall be along with the courses for the 7th semester. A report is to be submitted to the Head of the Department and evaluation (2 credit) will be based on the report and viva-voce examination. The examiners for the viva-voce examination shall be the Head of the Department and the program coordinator or their nominees.

Project Work# **(#Optional)**

B.13.0 Project Evaluation

The project evaluation shall be carried out by a Project evaluation committee comprising the Head of the Department or his/her nominee (Chairperson), Project coordinator (Professor / Associate Professor) and the project guide(s).

B.13.1 The continuous assessment of the project work is as follows:

Assessment	% weightage	Semester Schedule
Preliminary Review	10	End of 2nd week
Review I	20	End of 3rd Week
Review II	20	End of 10th Week
Final assessment	50	End of semester

B.13.2 At the completion of a project, the student will submit a project report which will be evaluated by duly appointed internal examiner(s). The evaluation will be based on the report and a Viva-voce examination on the project.

B. 9.2 Industrial Lectures

A course based on industrial lectures shall be offered for 1 credit. A minimum of five lectures of two hours' duration by industry experts will be arranged by the Department.

The evaluation methodology, will in general, be based on quizzes at the end of each lecture. Due weightage shall be given to attendance also. However, the HoD or her/his nominee may devise a suitable methodology for evaluation and the same should be informed to the students before the commencement of the semester.

It is recommended that the percentage of syllabus covered by the industrial experts shall be limited to 25 % for a given course. Prior approval must be obtained from the designated committee.

B. 10.3 Comprehensive Examination

The comprehensive examination in the final year of study shall have two objective tests of 25 marks each. The final examination shall have 50 marks. The examination will be of objective type similar to the GATE examination. A department committee comprising the Head of the Department or his/her nominee and two faculty members of the department shall conduct the examinations.

Semester I (July Session)

Sl. No.	Course Code	COURSE	Credits	Category
1.	ENIR11	Energy and Environmental Engineering	2	IR
2.	MAIR12	Linear Algebra and Calculus (Mathematics I)	3	IR
3.	PHIR11	Physics	3	IR
4.	PHIR12	Physics Laboratory	2	IR
5.	CSIR12	Introduction to Computer Programming (T + L)	3	IR
6.	MEIR11	Basics of Mechanical Engineering (for CE, EE, EC, **IC** & CS)	2	IR
7.	PRIR11	Engineering Practice	2	IR
8.	CEIR11	Basics of Civil Engineering (for EE, EC, **IC** & CS)	2	IR
		Total	**19**	

Semester II (January Session)

Sl. No.	Course Code	COURSE	Credits	Category
1.	HSIR11	English for Communication (Theory **AND** Lab)	4	IR
2.	MAIR22	Complex Analysis and Differential Equations (Mathematics II)	3	IR
3.	CHIR11	Chemistry	3	IR
4.	CHIR12	Chemistry Laboratory	2	IR
5.	ICIR15	Introduction to Instrumentation and Control Systems Engineering	2	IR
6.	MEIR12	Engineering Graphics	3	IR
7.	ICPC11	Thermodynamics and Fluid Mechanics (Programme Core – I)	4	PC
8.	SWIR11/ SWIR12/ SWIR13	NSS/ NCC/ NSO	0 (Pass/Fail)	IR
		Total	**21**	

Semester III (July Session)

Sl. No.	Course Code	COURSE	Credits	Category
1.	MAIR34 (for IC)	Probability and Distribution Theory (Mathematics III)	4	IR
2.	ICPC12	Circuit Theory (Programme Core – II)	4	PC
3.	ICPC13	Sensors and Transducers (Programme Core – III)	3	PC
4.	ICPC14	Digital Electronics (Programme Core – IV)	3	PC
5.	ICPC15	Signals and Systems (Programme Core – V)	3	PC
6.	ICPEXX	Programme Elective – I	3	PE/OE
7.	ICLR11	Thermodynamics and Fluid Mechanics Laboratory (Laboratory - I)	2	LR
8.	ICLR12	Circuits Laboratory (Laboratory - II)	2	LR
		Total	**24**	

Note: Department(s) to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 24 credits.

Semester IV (January Session)

Sl. No.	Course Code	COURSE	Credits	Category
1.	HSIR13	Industrial Economics and Foreign Trades	3	IR
2.	ICPC16	Control Systems - I (Programme Core – VI)	4	PC
3.	ICPC17	Analog Signal Processing (Programme Core – VII)	3	PC
4.	ICPC18	Microprocessors and Microcontrollers (Programme Core – VIII)	3	PC
5.	ICPEXX	Programme Elective – II	3	PE/OE
6.	ICPEXX	Programme Elective – III	3	PE/OE
7.	ICLR13	Sensors and Transducers Laboratory (Laboratory - III)	2	LR
8.	ICLR14	Analog Signal Processing Laboratory (Laboratory - IV)	2	LR
		Total	**23**	

Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3 credits to those willing students in addition to 23 credits.

Semester V (July Session)

Sl. No.	Course Code	COURSE	Credits	Category
1.	ICPC19	Control Systems - II (Programme Core – IX)	4	PC
2.	ICPC20	Industrial Instrumentation (Programme Core – X)	3	PC
3.	ICPC21	Electrical and Electronic Measurements (Programme Core – XI)	3	PC
4.	ICPC22	Process Control (Programme Core – XII)	3	PC
5.	ICPEXX	Programme Elective – IV	3	PE/OE
6.	ICPEXX	Programme Elective – V	3	PE/OE
7.	ICLR15	Control Engineering Laboratory (Laboratory - V)	2	LR
8.	ICLR16	Microprocessors and Microcontrollers Laboratory (Laboratory - VI)	2	LR
		Total	**23**	

Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3 credits to those willing students in addition to 23 credits.

Semester VI (January Session)

Sl. No.	Course Code	COURSE	Credits	Category
1.	ICIR19	Industrial Lecture	1	IR
2.	HSIR14	Professional Ethics	3	IR
3.	ICPC23	Biomedical Instrumentation (Programme Core – XIII)	3	PC
4.	ICPC24	Analytical Instrumentation (Programme Core – XIV)	3	PC
5.	ICPC25	Logic and Distributed Control Systems (Programme Core – XV)	3	PC
6.	ICPEXX	Programme Elective - VI	3	PE/OE
7.	ICPEXX	Programme Elective - VII	3	PE/OE
8.	ICLR17	Instrumentation Laboratory (Laboratory - VII)	2	LR
9.	ICLR18	Industrial Automation and Process Control Laboratory (Laboratory - VIII)	2	LR
		Total	**23**	

Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3 credits to those willing students in addition to 23 credits.

Semester VII (July Session)

Sl. No.	Course Code	COURSE	Credits	Category
1.	ICIR16	Summer Internship	2	IR
2.	ICPEXX	Programme Elective – VIII	3	PE/OE
3.	ICPEXX	Programme Elective – IX	3	PE/OE
4.	ICPEXX	Programme Elective – X	3	PE/OE
5.	ICPEXX	Programme Elective – XI	3	PE/OE
		Total	**14**	

Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3 credits to those willing students in addition to 14 credits.

Semester VIII (January Session)

Sl. No.	Course Code	COURSE	Credits	Category
1.	ICIR18	Comprehensive Viva Voce	1	IR
2.	ICPEXX	Programme Elective – XII	3	PE/OE
3.	ICPEXX	Programme Elective – XIII	3	PE/OE
4.	ICPEXX	Programme Elective – XIV	3	PE/OE
	ICIR19	Project Work#	6#	IR
		Total	**10**	

Optional

Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3 credits to those willing students in addition to 16 credits.

Credit Distribution

Semester	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
Credit	**19**	**21**	**24**	**23**	**23**	**23**	**14**	**10**	**157**

Note:

1. Curriculum should have 4 programme core courses which shall be 4 credits each.
2. B.Tech. Regulations 2019-

   B.7.0 The number of credits that a student can register in a semester is 28 credits, excluding Honours, Minor and Online Courses.

   B.2.5 Normally a semester shall have six theory courses and two laboratory courses. *From the fourth semester onwards, students can register for one additional theory (elective) course excluding Honours, Minor and Online Courses.*

   B 6.3 The B.Tech. students are also eligible to take additional regular courses apart from the courses prescribed in the curriculum, viz, one course in 5th, 6th, 7th semesters and not more than two courses in the 8th semester, provided a student has a CGPA of 7.0 & above, at the end of the previous semester. Students taking extra courses should obtain the prior approval of the Dean (Academic) with the consent of Head of the department.
3. Out of 14 elective courses (PE/OE), the students should study **at least eight** **programme elective (PE) courses.**
4. B 2.6 A student can register a **maximum of 12 credits as online courses** during the entire program of study. These shall be treated as Open Elective courses. Students are allowed to register online courses **starting from 3rd semester onwards**.
5. MI – Minor Degree: **15 credits over and above the required total credits** (157)

   B.2.8 A student can earn 15 credits, in addition to the credits specified by the department for B.Tech degree, as optional courses from the basket of minor electives offered by single department **from the 3rd semester**.
6. HO – Honours Degree: **15 credits over and above the required total credits** (157).
   B.2.7 B.Tech. (Honours) students can register for an additional course **from the 5th semester** from the basket of honours courses offered by the department concerned.
   B.27.0 Continued to maintain the CGPA of 8.5 in all semesters excluding honours courses.

Distribution of Courses

Semester	General Institute Requirements	Programme Core	Programme Elective	Essential Laboratory Requirements	Total
I	8	-	-	-	8
II	8	1	-	-	9
III	1	4	1	2	8
IV	1	3	2	2	8
V	-	4	2	2	8
VI	2	3	2	2	9
VII	1	-	4	-	5
VIII	1	-	3	-	4
Total	22	15	14	8	59

Distribution of Credits

Semester	General Institute Requirements	Programme Core	Programme Elective	Essential Laboratory Requirements	Total Credits
I	19	-	-	-	19
II	17	4	-	-	21
III	4	13	3	4	24
IV	3	10	6	4	23
V	-	13	6	4	23
VI	4	9	6	4	23
VII	2	-	12	-	14
VIII	1	-	9	-	10
Total Credits	50	49	42	16	157

LIST OF COURSES

I. PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ICPC11	Thermodynamics and Fluid Mechanics	-	4
2.	ICPC12	Circuit Theory	-	4
3.	ICPC13	Sensors and Transducers	-	3
4.	ICPC14	Digital Electronics	-	3
5.	ICPC15	Signals and Systems	-	3
6.	ICPC16	Control Systems - I	-	4
7.	ICPC17	Analog Signal Processing	-	3

8.	ICPC18	Microprocessors and Microcontrollers	ICPC14	3
9.	ICPC19	Control Systems - II	-	4
10.	ICPC20	Industrial Instrumentation	-	3
11.	ICPC21	Electrical and Electronic Measurements	-	3
12.	ICPC22	Process Control	ICPC16	3
13.	ICPC23	Biomedical Instrumentation	-	3
14.	ICPC24	Analytical Instrumentation	-	3
15.	ICPC25	Logic and Distributed Control Systems	-	3
				49

II. ESSENTIAL LABORATORY REQUIREMENT (LR)

Sl. No.	Course Code	Course Title	Corequisites	Credits
1.	ICLR10	Thermodynamics and Fluid Mechanics Laboratory	-	2
2.	ICLR11	Circuits and Digital Laboratory	-	2
3.	ICLR12	Sensors and Transducers Laboratory	-	2
4.	ICLR13	Analog Signal Processing Laboratory	-	2
5.	ICLR14	Control Engineering Laboratory	-	2
6.	ICLR15	Microprocessors and Microcontrollers Laboratory	-	2
7.	ICLR16	Instrumentation Laboratory	-	2
8.	ICLR17	Industrial Automation and Process Control Laboratory	-	2

III. ELECTIVES

a. PROGRAMME ELECTIVE (PE)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1	ICPE10	Instrumentation Practices in Industries	ICPC20	3
2	ICPE11	Optical Instrumentation	-	3
3	ICPE12	Measurement Data Analysis	-	3
4	ICPE13	Micro Electro Mechanical Systems	-	3
5	ICPE14	Automotive Instrumentation and Control	-	3
6	ICPE15	Instrumentation and Control for Power Plant	-	3

7	ICPE16	Instrumentation and Control for Petrochemical Industries	-	3
8	ICPE17	Instrumentation and Control for Paper Industries	-	3
9	ICPE18	Instrumentation for Agricultural and Food Processing Industries	-	3
10	ICPE19	Piping and Instrumentation Diagrams	ICPC20	3
11	ICPE20	Assistive devices	-	3
12	ICPE21	Medical Diagnostic and Therapeutic Instrumentation	-	3
13	ICPE22	Product Design and Development (Theory and Practice)	-	3
14	ICPE23	Digital Control Systems	-	3
15	ICPE24	Building Automation	-	3
16	ICPE25	Non-Linear Control	ICPC 19	3
17	ICPE26	System Identification	-	3
18	ICPE27	Fault Detection and Diagnosis	ICPC16	3
19	ICPE28	Computational Techniques in Control Engineering	ICPC19	3
20	ICPE29	Process Modeling and Optimization	-	3
21	ICPE30	Control System Components	-	3
22	ICPE31	Network Control Systems	-	3
23	ICPE32	Robotics	-	3
24	ICPE33	Power Electronics	-	3
25	ICPE34	Digital Signal Processing	ICPC15	3
26	ICPE35	Industrial Electric Drives	ICPE33	3
27	ICPE36	Real-Time Embedded Systems	ICPC18	3
28	ICPE37	Smart and Wireless Instrumentation	-	3
29	ICPE38	Principles of Communication Systems	-	3
30	ICPE39	Multi Sensor Data Fusion	-	3
31	ICPE40	Digital Image Processing	-	3
32	ICPE41	Biomedical Signal Processing	-	3

33	ICPE42	Medical Imaging Systems	-	3
34	ICPE43	Energy Harvesting Techniques	-	3
35	ICPE44	Smart Materials and Systems	-	3
36	ICPE45	Hydraulics and Pneumatics	-	3
37	ICPE46	Engineering Mechanics	-	3
38	ICPE47	Internet of Things System Design	-	3
39	ICPE48	Software Design Tools for Sensing and Control	-	3
40	ICPE49	Neural Networks and Fuzzy Logic	-	3
41	ICPE50	Industrial Data Communication	ICPE38	3
42	ICPE51	Numerical Methods	-	3
43	ICPE52	Electron Devices and Circuits	-	3
44	ICPE53	Data Structures and Algorithms	-	3
45	ICPE54	Nuclear Instrumentation	-	3
46	ICPE55	Condition Monitoring	-	3
47	ICPE56	Safety Instrumented System	-	3
48	ICPE57	Cyber Security for Industrial Automation	-	3

b. OPEN ELECTIVE (OE) - Online Courses for students of the department

A committee headed by the head of the department with two faculty members can decide the online courses to be offered to the students. A student can earn maximum of 12 credits from these courses.

S. No.	Course Name	Duration In Weeks	UG/PG	NOC URL	NPTEL URL
1	Laser: Fundamentals and Applications	8	UG/PG	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy13	https://nptel.ac.in/courses/104/104/104104085/
2	Data Analytics using Python	12	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs46/	https://nptel.ac.in/courses/106/107/106107220/
3	Deep Learning	12	UG/PG	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cs54	https://nptel.ac.in/courses/106/105/106105215/
4	Introduction to Internet of Things	12	UG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs22	https://nptel.ac.in/courses/106/105/106105166/
5	Programming, Data Structures and Algorithms Using Python	8	UG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs26	https://nptel.ac.in/courses/106/106/106106145/
6	Introduction to Machine Learning	12	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs29	https://nptel.ac.in/courses/106/106/106106139/

7	Introduction to Robotics	12	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-de11/	https://nptel.ac.in/courses/107/106/107106090/
8	Design, Technology and Innovation	8	UG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-de03/	https://nptel.ac.in/courses/107/101/107101088/
9	Fabrication Techniques for MEMs-based sensors: clinical perspective	12	UG	https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-ee36	https://nptel.ac.in/courses/108/108/108108113/
10	Electronics Equipment Integration and Prototype building	8	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee01/	https://nptel.ac.in/courses/108/108/108108157/
11	Embedded System Design with ARM	8	UG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs15/	https://nptel.ac.in/courses/106/105/106105193/
12	Fiber Optics	8	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ph07/	https://nptel.ac.in/courses/115/107/115107095/
13	Industrial Automation and Control	12	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-me39/	https://nptel.ac.in/courses/108/105/108105088/
14	Process Control - Design Analysis and Assessment	12	UG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ch11/	https://nptel.ac.in/courses/103/106/103106148/
15	Robotics and Control: Theory and Practice	8	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-me03/	https://nptel.ac.in/courses/112/107/112107289/
16	Introductory Neuroscience & Neuro-Instrumentation	12	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ee95/	https://nptel.ac.in/courses/108/108/108108167/
17	Innovation, Business Models and Entrepreneurship	8	UG/PG	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-mg55	https://nptel.ac.in/courses/110/107/110107094/
18	Robotics	8	UG/PG	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-me74	https://nptel.ac.in/courses/112/105/112105249/
19	Automation in Manufacturing	12	UG/PG	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-me58/	https://nptel.ac.in/courses/112/103/112103293/
20	BioMEMS and Microfluidics	8	UG/PG	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-me38	https://nptel.ac.in/courses/112/104/112104181/
21	Applied Linear Algebra for Signal Processing, Data Analytics and Machine Learning	12	UG/PG	https://onlinecourses.nptel.ac.in/noc21_ee33/preview	https://nptel.ac.in/courses/108/104/108104174/
22	Reinforcement Learning	12	UG/PG	https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-cs27/	https://nptel.ac.in/courses/106/106/106106143/

23	Op-Amp Practical Applications: Design, Simulation, and Implementation	12	UG/PG	https://onlinecourses.nptel.ac.in/noc20_ee55/preview	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ee39
24	Introduction to Fuzzy Set Theory, Arithmetic and Logic	12	UG/PG	https://onlinecourses.nptel.ac.in/noc20_ma48/preview	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ma31
25	Robotics: Basics and Selected Advanced Concepts	12	UG/PG	https://onlinecourses.nptel.ac.in/noc21_me37/preview	https://nptel.ac.in/courses/112/108/112108298/
26	Sensors and Actuators	12	UG/PG	https://onlinecourses.nptel.ac.in/noc21_ee32/preview	https://nptel.ac.in/noc/courses/noc19/SEM2/noc1
27	Model Predictive Control: Theory and Applications	12	UG/PG	https://onlinecourses.nptel.ac.in/noc21_ge01/preview	https://nptel.ac.in/courses/127/106/127106225/

Note: In case any of the above listed courses are not offered in Swayam in that semester, the department will notify alternative courses offered in Swayam

IV. ADVANCED LEVEL COURSES (HO) for B.Tech. (HONOURS)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ICHO10	Design of Sensors and Transducers	ICPC13	4
2.	ICHO11	Instrumentation System Design	ICPC20	4
3.	ICHO12	Micro System Design	ICPE13	4
4.	ICHO13	Control System Design	ICPC16, ICPC19	4
5.	ICHO14	Advanced Process Control	ICPC16, ICPC22	4
6.	ICHO15	Optimal and Robust Control	ICPC16, ICPC19	4
7.	ICHO16	Sensors Systems Design	ICPC17	4

V. OPEN ELECTIVE (OE) (offered for the students of other departments)

The courses listed below are offered by the Department of **Instrumentation and Control Engineering** for students of other Departments.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ICOE10	Bio Medical Instrumentation	-	3
2.	ICOE11	Biomedical Signal Processing	-	3
3.	ICOE12	Micro Electro Mechanical Systems	-	3

4.	ICOE13	Measurement and Control	-	3
5.	ICOE14	Industrial Measurements	-	3
6.	ICOE15	Virtual Instrument Design	-	3
7.	ICOE16	Neural Networks and Fuzzy Logic	-	3
8.	ICOE17	Network Control Systems	-	3
9.	ICOE18	Control Systems	-	3
10.	ICOE19	Energy Harvesting Techniques	-	3
11.	ICOE20	Smart Materials and Systems	-	3
12.	ICOE21	Product Design and Development (Theory and Practice)	-	3
13.	ICOE22	Medical Imaging Systems	-	3
14.	ICOE23	Building Automation	-	3

VI. MINOR (MI) (offered for the students of other departments)

Students who have registered for B.Tech. **Minor in Instrumentation and Control Engineering** can opt to study any 5 of the courses listed below.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ICMI10	Transducer Engineering	-	3
2.	ICMI11	Test and Measuring Instruments	-	3
3.	ICMI12	Measurements in Process Industries	-	3
4.	ICMI13	Essentials of Control Engineering	-	3
5.	ICMI14	Industrial Automation and Control	-	3
6.	ICMI15	Digital Electronics	-	3
7.	ICMI16	Microprocessor and Microcontroller	-	3
8.	ICMI17	Micro Electro Mechanical Systems	-	3

Department Codes

1.	Chemical Engineering	CL
2.	Civil Engineering	CE
3.	Computer Science and Engineering	CS
4.	Electrical and Electronics Engineering	EE
5.	Electronics and Communication Engineering	EC
6.	Instrumentation and Control Engineering	IC
7.	Mechanical Engineering	ME

8.	Metallurgical and Materials Engineering	MT
9.	Production Engineering	PR
10.	Chemistry	CH
11.	Computer Applications	CA
12.	Humanities and Social Sciences	HS
13.	Energy and Environment	EN
14.	Management Studies	MB
15.	Mathematics	MA
16.	Physics	PH

GENERAL INSTITUTE REQUIREMENT (IR)

Department Specific IR (other than first-year courses)

ICIR15 – INTRODUCTION TO INSTRUMENTATION AND CONTROL SYSTEMS ENGINEERING (Branch Specific Course)

Course Type:	IR	***Pre-requisites:* -**
No. of Credits:	2	

Course Objectives

To introduce the students on the role of Instrumentation and Control Engineering in the society.

Course Content

Place of engineers in the society and in an industrial organization. The technical manpower pyramid. Introduction to the program, subjects of study and its relevance, Opportunities for training, placement and for higher studies.

Overview of industry and scope of the discipline - Preliminary project design requirements – Various process conditions. Knowing client requirement and collection of specific data for projects.

Objectives, general concepts, terminologies, types and basic block diagram of instrumentation system.

Introduction to instrumentation and control engineering codes and standards and their relevance to industry.

Case studies: Introduction to instrumentation and control in a typical application like temperature, flow or pressure control.

Text Books

1. Alan S Moris, Measurement and Instrumentation Principles, Butterworth-Heinemann Limited, 3rd Edition, 2001
2. Bolton W, Industrial Control and Instrumentation, University Press, Fi1st Edition, 2005.
3. Chesmond C J, Basic Control System Technology, Viva Books Private Limited, 1998.

Reference Books

1. ISA standards
2. Bureau of Indian Standards

Course Outcomes

1. Students will know what an engineer does for the benefit of society.
2. Role of instrumentation and control engineering in an industrial organization.
3. They will know instrumentation and control engineering in a device or a plant.
4. They will know standards used in instrumentation and control engineering.
5. They will know how to apply basic building blocks of instrumentation and control engineering for a typical application.

MAIR34 – PROBABILITY AND DISTRIBUTION THEORY

Course Type: IR ***Pre-requisites:*** -

No. of Credits: 4

Course Objectives

To formally introduce the ideas of uncertainty and randomness that prevail in measurements and generation of controlled sequences in engineering applications. The course objective is to

1. Familiarize basic concepts of probability and random variables
2. Identifying and analyzing random variables in practical problems
3. Introduce important probability distributions for analyzing the data
4. Evaluate the mean, variance and moments of random variables
5. Solve real-world problem using probability techniques.

Course Content

Introduction to Basic Probability, Review of set theory and combinatorics, binomial probability law, computer simulations of real-world examples – communications and quality control, Conditional Probability, Joint events, statistically independent events, Bayes theorem, applications to cluster recognition

Probability of discrete random variables, Important probability mass functions (PMFs), Approximation of the binomial PMF with Poisson PMF, Transformations, Cumulative distribution functions, expected values of discrete random variables, functions of discrete random variables, variance and moments, characteristic functions, estimating means and variances, applications to data compression

Jointly distributed random variables, expectations, joint moments, prediction of outcomes, joint characteristic functions, Conditional PMFs.

Continuous random variables, expectations, Conditional probability density functions, continuous N- dimensional random variables, applications to signal detection.

Probability and moment approximations, Law of large numbers, central limit theorem, applications to cooperative control and opinion polling.

Text Books

1. M.C. Douglas, and R.C. George, Applied Statistics and Probability for Engineers, 7^{th} Edition, Wiley,2018
2. S. M. Kay, Intuitive Probability and Random Processes using MATLAB, Springer, 2017
3. S. Ross, Introduction to Probability and Statistics for Engineers and Scientists, 5^{th} Edition, Elsevier,2014
4. Y. Viniotis, Probability and Stochastic Processes for Electrical Engineers, Tata McGraw Hill,1998

Reference Books

1. M. Evans and J. Rosenthal, Probability and Statistics: The Science of Uncertainty, 2^{nd} Edition, WH Freeman, 2010
2. P. Olofson, Probabilities: The Little Numbers that Rule our Lives, Wiley,2007

Course Outcomes:

On successful completion of the course students will be able to

1. Identify an appropriate probability distribution for a given discrete or continuous random variable and use its properties to calculate probabilities
2. Evaluate probabilities for joint distributions including marginal and conditional probabilities
3. Evaluate mean, variance and moments of the random variables
4. Derivetheprobabilitydensityfunctionofrandomvariablesandusetechniquestogeneratedat a from various distributions
5. Translate real-world problems into probability models and apply probability and statistical techniques for solving them.

HSIR13 – INDUSTRIAL ECONOMICS AND FOREIGN TRADE

Course type: IR **_Pre-requisites_:** -
No. of Credits: 3

Course Objectives

The course intends
1. To provide knowledge to the students on the basic issues such as productivity, efficiency, capacityutilization and debates involved in industrial development;
2. To give thorough knowledge about the economics of industry in a cogent and analytical manner.

Course Content

Demand Analysis and Forecasting: Cardinal Ordinal Approaches. Demand and Supply, Elasticities, Forecasting techniques, Consumer behavior.

Production, Cost, and Market structure: Variable proportions, Returns to Scale, Isoquants Analysis, Production Function, Cost Curves, Cost Function, Market Analysis and game theory.

Types, Location, Efficiency and Finance: Mergers and Amalgamations, Location of Industries and Theories, Productivity and Capacity Utilization, Shares, Debentures, Bonds, Deposits, Loan etc. FDI, Foreign Institutional Investment, Euro Issues, GDR, ADR, External Commercial Borrowings.

Introduction: Features of International Trade. Inter-regional and international Trade. Problems of International Trade. Theories

Terms of Trade- Concept, Measurement, Types, Factors affecting Terms of Trade, Exchange rate.

Free Trade, Protection and Tariffs, Balance of Payments**:** Free Trade, Protection-Quotas, Dumping, etc. Balance of Trade and Balance of Payments.

Regional Economic Groupings and International Institutions: BRICS, EU, SAARC, OPEC, ASEAN. International Institutions: GATT, WTO, UNCTAD, IBRD, IMF.

References

1. Chauhan, S.P.S. Micro Economics, An Advanced Treaties, PHI,2011.
2. Jhingan, M.L. International Economics. VrindaPublications,2016.
3. Francis Charunilam. International Economics-Graw Hill, 5th Edition,.2017.
4. Paul, Krugman. International Economics. Pearson, 10th Edition,2017.
5. Kenneth D. George. Industrial Organization, Routledge,2009.

Course outcomes

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

1. Define micro economics, demand analysis, supply analysis, consumption laws,in difference curve analysis and competitions.
2. Get knowledge on macroeconomics; differentiate with micro economics, importance,Keynes theory, functions of central and commercial bank.
3. To know the Contributions of Fayol, Taylor' managerial functions, balance sheet, andsources of finance.
4. Differentiate marketing and selling, marketing myopia, and product lifecycle.
5. Describe recruitment and selection, job evaluation and performance appraisal methods, communication, motivation and leadership.

HSIR14 – PROFESSIONAL ETHICS

Course type:	IR	***Pre-requisites*:**	-
No. of Credits:	3		

Course Objectives

1. To identify the core values that shapes the ethical behavior of an engineer.
2. To relate the code of ethics to social experimentation.
3. To understand the difference between moral standards and professional ethics.
4. To evaluate the need for computer ethics.
5. To appreciate the rights of others

Course Content

Introduction to Ethics, Moral and Values

Occupation-Profession-Professionalism-Concept of Ethics-need for Ethics in Engineering - impact of unethical conducts on society and professional - Importance of Moral and Value in profession – core values, Hollow values and its impact - Work Ethics – Styles of Ethics -Service Learning, components, reflections, evaluation and its assessment–Civic Virtue - Respect for Others in Engineering Work Place– Living Peacefully – Caring and Sharing in engineering –- General Etiquette for students

Ethical Theories and Engineering

Kohlberg's theory – Gilligan's theory- utilitarianism and Cost Benefit analysis – Duty Ethics and RightEthics-ItsImpactonEngineeringPractices– VirtueEthicsandPersonalvs.CorporateMorality--moral autonomy — Consensus and Controversy - Moral issues in Engineering – types of inquiry – moraldilemmas – Ethical Problem-Solving Techniques - Types of Issues in Engineering and Ethical ProblemSolving - line-drawing technique, flow charting method with examples and applications - conflict problem solving methods - Models of Professional Roles andProfessionalism

Engineering Projects and Expected Traits

Engineering as experimentation – engineers as responsible experimenters – Codes of ethics - Researchethics– Industrial Standard – purpose, types and use - Balanced outlook on law – – Collegiality and loyalty–respectforauthorityinindustry–collectivebargaining–Confidentiality–conflictsofinterest and conflicting interest

Safety, Responsibilities and Rights

Safetyandrisk–definition-subjectivenatureanddependingfactors-typesofrisks–typesofsafetyin industry- Riskbenefitanalysisandreducingrisk–Govt.Regulator'sapproachtorisks-thechallenger case study – the three mile island and Chernobyl case studies and Bhopal UCC accident – causes, ethical and safety issues – Accidents and Engineer's role - Designing for Safety - Threat of Nuclear Power – depletion of ozone, greenery effects – occupational crime – professional rights – employees' rights – whistle- blowing – condition and types of whistle blowing - Confidentiality and Proprietary Information
- Intellectual Property Rights (IPR)

Ethics in Present Scenario and Engineers Role

Multinational corporations – Business ethics – Environmental ethics – computer ethics – Role in Technological Development – Ethics for Weapons development – engineers as managers – consulting engineers – engineers as expert witnesses and advisors – Leadership - sample code of conduct ethics like ASME, ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management, Institution of Electronics and Telecommunication Engineers (IETE), India, etc.,

Text Books

1. Mika Martin and Roland Scinger, Ethics in Engineering, Pearson Education/Prentice Hall, 3rd Edition, 2017.
2. Govindarajan M., Natarajan S., Senthil Kumar V. S., Engineering Ethics, Prentice Hall of India, New Delhi,2004.
3. CharlesD.Fleddermann, Ethics in Engineering, Pearson Education/Prentice Hall, NewJersey,2004(Indian Reprint).
4. Charles E. Harris, Michael S. Protchard and Michael J. Rabins, Engineering Ethics – Concept andCases, Wadsworth Thompson Learning, United States, 2000 (Indian Reprint now available).
5. Concepts and Cases, Thompson Learning (2000).
6. John R. Boatright, Ethics and Conduct of Business, Pearson Education, New Delhi,2003.
7. Edmund G. Seebauer and Robert L. Barry, Fundamentals of Ethics for Scientists and Engineers,Oxford University Press , 2001.

Course Outcomes

1. The students will understand the basic perception of profession, professional ethics, andvarious moral and social issues.
2. Students will be aware of their rights and responsibility as engineers.
3. Students will acquire knowledge about various roles of engineers in a variety of globalissues.
4. Students will have the ability to thrive in competitive professional spaces with integrityand responsibility.
5. They will learn to be empathetic and assertive leaders in their respective profession.

PROGRAMME CORE (PC) COURSES

ICPC11 - THERMODYNAMICS AND FLUID MECHANICS

Course type:	Programme Core (PC)	***Pre-requisites*:**	-
No. of Credits:	4		

Course Objectives

1. To impart knowledge about the fundamentals of thermodynamic laws, concepts and principles.
2. To introduce the principles of various cycles and to apply the thermodynamic concepts in various applications.
3. To introduce the fundamental concepts of fluid mechanics, pressure distribution and dimensional analysis.
4. To comprehend the metering and transportation of fluids and fluid moving machinery performance.

Course Content

Basic concepts of thermodynamics: Thermodynamic equilibrium, quasi-static process, zeroth law, work and heat interactions, first law for a cycle and a process, steady flow processes, second law statements, reversibility, Carnot theorem, Clausius inequality, entropy principle. Available energy: Availability and irreversibility, properties of pure substances, phase equilibrium diagrams, Rankine cycle, reheat and regenerative cycle, properties of ideal gas, Stirling and Ericson cycles.

Heat engines: Otto, diesel and dual cycles, Brayton cycle with regeneration, inter cooling and reheat, Joule-Thompson effect.

Fundamentals of Fluid mechanics: Classification of fluids and their physical properties, Fluid statics, manometers, pressure on submerged bodies**.** Ideal fluid - velocity field - stream line, streak line and path line, continuity equation - Rotational and irrotational flow, stream function and potential function, Euler's equations of motion, Bernoulli's equation and its application. Classification of open channel flows - measurement of discharge using rectangular and V-notches. Dimensional analysis – Rayleigh's method - Buckinghan Theorem and its applications. Laminar flow – Losses – Hagen-Poiseuille equation – Turbulent pipe flow – Friction.

Darcy Weisbach equation – Moody's diagram, minor losses – Boundary layer and its basic concepts.

Fluid machinery: Centrifugal pumps, Reciprocating pumps, Hydraulic ram, Impulse turbine, Reaction turbine.

Text Books

1. Zemansky, Heat and Thermodynamics, McGraw Hill, New York, 7th Edition, 1997.

1. Ojha C.S.P., Berndtsson R., Chandramouli P.N., Fluid Mechanics and Machinery, Oxford University Press, 2010.
2. Streeter V.L. and Wylie E.B., Fluid Mechanics, McGraw Hill, New York, 9th Edition, 1997.

Reference Books

1. Van Wylen G.A., Fundamentals of classical Thermodynamics, John Wiley and Sons, 4th Edition, 1994.

2. Cengal Y.A., Bogles M.A., Micheal Boles, Thermodynamics, McGraw Hill Book Company, 2nd Edition, 1994.
3. Nag P.K., Engineering Thermodynamics, Tata McGraw Hill, 2nd Edition, 1995.
4. Crowe C.T., Elger D.F., Williams B.C., Roberson J.A., Engineering Fluid Mechanics John Wiley andSons, 9th Edition, 2009.
5. S. K. Som, Gautam Biswas, Suman Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, 3rd Edition. Tata McGraw-Hill Education. (2013)

Course outcomes

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

1. Apply the fundamentals of thermodynamics to various process.
2. Understand various thermodynamic cycles and their applications to heat engines.
3. Apply the knowledge of fundamental concepts in fluids mechanics and usage of dimensional analysis for scaling experimental results.
4. Select the metering equipment and fluid moving machinery for an appropriate process engineering operation.

ICPC12 – CIRCUIT THEORY

Course type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 4

Course Objectives

1. To teach the electrical circuit laws and theorems, to aid in circuit analysis.
2. To impart problem solving technique of linear passive electrical circuits.
3. To expose the students to the transient behaviour of different R-L-C circuits.
4. To teach the methods of AC circuit analysis and synthesis of 2-port networks.

Course Content

Review of Networks and Circuits, Elemental laws (V-I characteristics) for Resistors, Inductors, and Capacitors, Circuital laws (Kirchhoff's laws), Sign convention, Basic signals (dc and ac), Elementary signals (impulse, step, ramp, exponential), Synthesis of arbitrary waveforms (rectangular, triangular etc.) from elementary signals, Voltage and Current sources (Independent and Dependent), Ladder and Bridge Circuits.

Analysis of Resistive Circuits energized by dc voltages and currents – Source Transformations, Nodal and Mesh Analysis, Principle of Superposition, Network Theorems (Thevenin's and Norton's, MaximumPower Transfer), Circuits with dependent dc Sources.

Transients with Energy Storage Elements, First and Second Order Circuits – Time-constant, Damping Ratio, Natural Frequency, Emphasis on Linear Ordinary Differential Equations, Step response of RC, RL, and RLC (series and parallel) Circuits, Resonance in Second Order Circuits.

Sinusoidal Sources and Response – Behavior of elements with ac signals, Impedance and Admittance, Generalization of Network Theorems and Circuit Analysis, Introduction to 3-φ power systems. Transient and Steady-state Response of Circuits – Laplace Transformation and its application to circuit analysis, State Variables, Network Functions (Driving point impedance and admittance), Transfer function, Two- port Networks, Applications of Two-port networks, Introduction to General Linear Systems.

Network Synthesis: Properties of RC, RL, and LC driving point functions, Synthesis of networks from given transfer functions.

Text Books

1. Hayt, W.H, Kemmerly J.E. and Durbin, Engineering Circuit Analysis, McGraw Hill Publications, 8^{th}Edition, 2013.
2. Franklin F. Kuo, Network Analysis and Synthesis, Wiley International, 5^{th} Edition, 2012
3. Van Valkenburg, Network Analysis, Prentice Hall, Revised 3^{rd} Edition,2019.

Reference Books

1. Charles K. Alexander, Mathew N.O Sadiku, Fundamentals of Electric Circuits TMH Education Pvt. Ltd, 5^{th} Edition, 2013.
2. Ramakalyan, A., Linear Circuits: Analysis and Synthesis, Oxford Univ. Press, 2005.
3. DeCarlo, R.A. and Lin, P.M., Linear Circuit Analysis: Time Domain, Phasor and Laplace Transform Approaches, Oxford University Press. 3rd Editions,2009
4. SC Dutta Roy, Circuit Theory, NPTEL video lectures

Course outcomes:

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

1. Analyze and solve the basic circuits using mesh and node analysis
2. Analyze and solve the DC and AC circuits using network theorems and mathematical tools
3. Apply the knowledge of the time domain and frequency domain characteristics of electrical circuits for design
4. Apply Laplace Transform for circuit analysis
5. Design and synthesis two port networks

ICPC13 - SENSORS AND TRANSDUCERS

Course type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To expose the students to various sensors and transducers for measuring mechanical quantities.
2. To make the students familiar with the specifications of sensors and transducers.
3. To teach the basic conditioning circuits for various sensors and transducers.
4. To introduce about advancements in sensor technology.

Course Content:

General concepts and terminology of measurement systems, transducer classification, general input-output configuration, static and dynamic characteristics of a measurement system, Statistical analysis of measurement data.

Resistive transducers: Potentiometers, metal and semiconductor strain gauges and signal conditioning circuits, strain gauge applications: Load and torque measurement.
Self and mutual inductive transducers- capacitive transducers, eddy current transducers, proximity sensors.

Piezoelectric transducers and their signal conditioning, Ultrasonic sensors, Seismic transducer and its dynamic response, seismic accelerometers, Force-Balance transducers: Theory-servo systems for measurement of non-electrical quantities.

Photoelectric transducers, Digital displacement sensors: Position Encoders, Variable frequency sensors, Tacho-generators and stroboscope, Hall effect sensors, Magnetostrictive transducers.

Introduction to semiconductor sensor, materials, scaling issues and basics of micro fabrication. Smart sensors. Introduction to flexible sensors and sensor fusion.

Text Books:

1. John P. Bentley, Principles of Measurement Systems, Pearson Education, 4th Edition, 2005.
2. Doebelin E.0, Measurement Systems - Application and Design, McGraw-Hill, 4th Edition, 2004.
3. S.M. Sze, Semiconductor sensors, John Wiley and Sons Inc., 3rd edition, 2006.

Reference Books:

1. James W. Dally, Instrumentation for Engineering Measurements, Wiley, 2nd Edition,1993
2. John G. Webster, Sensors and Signal Conditioning, Wiley Inter Science, 2nd edition,2008
3. Patranabis, Sensors and Transducers, Prentice Hall, 2nd edition,2003.
4. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd,2011.
5. Murthy D. V. S, Transducers and Instrumentation, Prentice Hall, 2nd Edition,2011
6. Neubert H.K.P, Instrument Transducers - An Introduction to their Performance and Design, Oxford University Press, 2nd Edition,1999.
7. Waldemar Nawrocki, Measurement Systems and Sensors, Artech House,2005

8. B.E. Noltingk, Instrumentation Reference Book, Butterworth- Heinemann, 2nd Edition 1995.
9. Kirianaki N.V., Yurish S.Y., ShpakN.O., Deynega V.P., Data Acquisition and Signal Processing for Smart Sensors, John Wiley and Sons, Chichester, UK, 2002.

Course outcomes:

On completion of this course, the students will be,

1. Familiar with the basics of measurement system and its input, output configuration.
2. Familiar with both static and dynamic characteristics of measurement system.
3. Familiar with the principle and working of various sensors and transducers.
4. Able to design signal conditioning circuit for various transducers.
5. Able to identify or choose a transducer for a specific measurement application.

ICPC14 - DIGITAL ELECTRONICS

Course type: Programme Core (PC) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

The subject aims to provide the student with

1. An understanding of number systems, codes and their conversions.
2. The capability to reduce Boolean expression using K-map and tabular methods.
3. The ability to design and analyze combinational and sequential logic circuits for a given problem statement.
4. An understanding of digital hardware, different types of logic families and their characteristics

Course Content:

Review of number systems and logic gates, Algebraic reductions, Binary codes -Weighted and non-weighted, number complements, Binary arithmetic, Error detecting and error correcting codes, SOP, POS Canonical logic forms, Karnaugh maps and Quine-McClusky methods, Don't care conditions, minimization of multiple output functions.

Synthesis of combinational functions: Arithmetic Circuits-Adder/ Subtractor, carry look-ahead adder, signed number addition and subtraction, BCD adders. IC adders. Multiplexers, implementation of combinational functions using multiplexers, de-multiplexers, decoders, code converters, Digital ICs for combinational logic circuits.

Sequential Logic: Basic latch circuit, Debouncing of a switch, Flip-Flops: truth table and excitation table, conversion of Flip-flops, integrated circuit flip-flops. Race in sequential circuits, Shift Registers, Counters - Synchronous, Asynchronous, Up-Down, Design of counters.

Analysis of clocked sequential circuits, Design with state equations, Moore and Mealy graphs, State reduction and assignment, Sequence detection, Hazards. Complexity and propagation delay analysis of circuits. Programmable logic devices, Design using Programmable Logic Devices (PLA, PAL, CPLD and FPGA).

Digital Hardware: Logic levels, Realization of logic gates, different logic families (TTL, ECL, CMOS, HC, HCT, ACT and HSCMOS), Logic levels, voltages and currents, fan-in, fan-out, speed, power dissipation. Comparison of logic families, interfacing between different families.

Text Books:

1. M. Morris Mano, Charles Kime, Tom Martin, Logic and Computer Design Fundamentals, Pearson, 5th Edition, 2016.
2. J.P. Uyemura, A First Course in Digital Systems Design: An Integrated Approach, Nelson Engineering, 1999.

3. W. H. Gothmann, Digital Electronics - An Introduction to Theory and Practice, Prentice Hall of India,2nd Edition, 2000

Reference Books:

1. J.M. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall of India, 2nd Edition, 2003.
2. N.H.E. Weste, and K. Eshraghian, Principles of CMOS VLSI Design: A Systems Perspective, Pearson Education Inc., (Asia), 3rd Edition, 2005.
3. S. Brown and Z Vranesic, Fundamentals of Logic Design with VHDL Design, Tata McGraw- Hill ,2002
4. V. P. Nelson, H.T. Nagle, E.D. Caroll and J.D. Irwin, Digital Logic Circuit Analysis and Design, Prentice Hall International, 1995
5. Anil K Maini, Digital Electronics: Principles and Integrated Circuits , Wiley, 2019
6. Thomas L. Floyd, Digital Fundamentals , 11th Edition, Pearson, 2015
7. Ronald J. Tocci, Widmer Neal, Moss Greg, Digital Systems- Principles and Applications,12th Edition, Prentice Hall, 2010

Course outcomes:

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

1. Understand various number systems, conversions and simplify the logical expressions using Boolean functions.
2. Design and develop arithmetic and other special functions using combinational logic circuits and PLDs.
3. Design and develop synchronous and asynchronous for the given problem statement.
4. Understand how logic gates are built from the fundamental semiconductor electronics and be able to select logic ICs from different families based on requirement.

ICPC15 - SIGNALS AND SYSTEMS

Course type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To introduce the student to identify and represent the type of signals and systems.
2. To introduce the mathematical tools available to analyze continuous time signals and systems.
3. To introduce the mathematical tools available to analyze discrete time signals and systems.
4. To introduce about the random phenomena in the real world, the mathematical models and pseudo-random signals in identifying systems.

Course Content:

Introduction to signals – Transformation of the independent variable – Basic continuous-time signals – Basic discrete-time signals – Step and Impulse functions – Sampling theorem. Introduction to systems – Properties of systems – Classification of systems – Mathematical model of systems – Concept of state variable – Normal form of system equations – Initial conditions.

Impulse response of physical systems – Stability analysis of dynamic systems – Introduction to convolution – Convolution integral – System impulse response and step response using Laplace transform – Numerical convolution. Z-transform – Convergence of Z-transform – Properties of Z-transform – Inversion of Z-transform –Application of Z-transform in analysis of discrete-time systems – Evaluation of discrete-time system frequency response – Inverse systems – Deconvolution.

Representation of signals in terms of elementary signals – Condition of orthogonality – Representation of signals by elementary sinusoids – Fourier series representation of periodic signals – Power spectrum.

Fourier transform – System frequency response – Realizability of frequency response – Energy spectrum. Calculation of simple transforms. Discrete-Fourier transform (DFT) – Properties of Discrete Fourier Transform – Circular convolution.
Classification of random signals – Auto-correlation function – Properties of auto-correlation function – Measurement of auto-correlation function – Application of auto-correlation functions. Cross correlation functions. Sum of random processes- Spectral density – Relation of spectral density to auto-correlation function

Auto-correlation function of system output - Cross-correlation between system input and output. White noise - Analysis of linear systems in time-domain using white noise - Mean and mean square value of system output. Generation of pseudo random binary noise (PRBN) and its use in system identification - Analysis in the frequency domain.

Text Books:

1. Gabel R.A. and Robert R.A., Signals and Linear Systems, John Wiley and Sons, 3^{rd} Edition, 1987.
2. Oppenheim A.V., Wilsky and Nawab, Signals and Systems, Pearson India Education Services Private limited India, 2^{nd} Edition, 2016.
3. Chen C.T., Systems and Signal Analysis - A Fresh Look, Oxford University Press India, 3^{rd} Edition, 2004.
4. B.P. Lathi, Principles of Linear Systems and Signals, Oxford University Press, 2^{nd} Edition, 2009

Reference Books:

1. Cooper G.R and Mc Gillem C.D, Probabilistic Methods of Signals and System Analysis, Oxford University Press, 3^{rd} Edition, 1999.
2. Chesmond, Wilson and Lepla, Advanced Control System Technology, Viva Books, 1^{st} Edition, 1998.
3. Ziemer R.E., Tranter W.H., and Fannin D.R., Signals and Systems: Continuous and Discrete, Prentice Hall, 4^{th} Edition, 1998.
4. Oppenheim, Alan V and Verghes, G.G., Signals, Systems and Inference – Class Notes for 6.011: Introduction to Communication, Control and Signal Processing, MIT Open Courseware.

Course outcomes:

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

1. Classify the signals and systems based on their properties and determine the response of LTI system using convolution
2. Analyze the spectral characteristics of continuous and discrete time signals and systems using Fourier transforms.
3. Apply Laplace and Z transform to analyze continuous and discrete time systems
4. Understand the process of sampling and the effects of under sampling
5. Classify random signals using statistical concepts and characterize systems using pseudo-random signals.

ICPC16 - CONTROL SYSTEMS - I

Course type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 4

Course Objectives:

1. To introduce the concept of feedback control system.
2. To impart knowledge in mathematical modeling of physical systems.
3. To impart knowledge in characteristics and performance of feedback control system.
4. To teach a variety of classical methods and techniques for analysis and design of control systems.

Course Content:

Review of Systems, Mathematical Models – Differential Equations, Linear Approximations and Transfer Functions, Block Diagrams and Signal Flow Graphs

Feedback Control System Characteristics, and Performance Specifications on transients and steady-state, Stability of Linear Feedback Systems – Routh-Hurwitz criterion.

The Root Locus Method, Feedback Control System Analysis and Performance Specifications in Time-Domain, Design of Lead, Lag, and PID Controller using Root Locus.

Frequency Response Methods, Nyquist's Stability Criterion, Bode Plots, Performance Specifications in Frequency-Domain, Stability Margins.
Design of Lead, Lag and PID controller in Frequency Domain.

Text Books

1. Dorf, R.C., Bishop, R.H., Modern Control Systems, Prentice Hall, 13th Edition,2016.
2. Katsuhiko Ogata, Modern Control Engineering, PHI Learning Private Ltd,5th Edition,2017.
3. Franklin, G.F., David Powell, J., Emami-Naeini, A., Feedback Control of Dynamic Systems, Prentice Hall, 8th Edition,2018.
4. M. Gopal, Control Systems: Principles and Design, Mc Graw Hill Publication,4th Edition, 2012

Reference Books

1. Nise, N.S., Control Systems Engineering, Wiley, 7th Edition,2018.
2. Golnaraghi, B.C. Kuo., Automatic Control Systems, 10th Edition, McGraw-Hill Education, 2018.
3. Nagrath, M. Gopal, Control Systems Engineering, 6th Edition, New Age International Publishers, 2017.
4. Anish Deb, Srimanti Roy choudhury., Control System Analysis and Identification with MATLAB, Block Pulse and Related Orthogonal Functions., CRC Press 1st Edition, 2018.
5. Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado., "Control System Design", 13th Edition, Prentice Hall Publication. 2000.
6. N Sivanandam and S N Deepa., Control Systems Engineering Using MATLAB, Vikas Publishing, 2nd Edition, 2018.

Course outcomes:

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

1. Generate mathematical models of dynamic control system by applying differential equations.
2. Analyze and characterize the behavior of a control system in terms of different system, performance parameters and assess system stability.
3. Evaluate and analyses system performance using frequency and transient response analysis.
4. Design and simulate control systems (linear feedback control systems, PID controller, and multivariable control systems), using control software, to achieve required stability, performance and robustness.

ICPC17 - ANALOG SIGNAL PROCESSING

Course type:	Programme Core (PC)	***Pre-requisites:***	-
No. of Credits:	3		

Course Objectives:

1. To teach the properties of analog signals and systems and random signal analysis
2. To familiarize the students to DC and AC characteristics of operational amplifiers and its influence on outputand their compensation techniques
3. To impart the students to design signal conditioning circuits using Op-Amp
4. To introduce the concepts of switched capacitor filters, Voltage regulator and PLL and its applications

Course Content:

Introduction to analog signals and systems, Random signal analysis, application of statistical methods to the measurement of waveforms.

Analog signal processing circuits: amplifiers, analog multipliers, integrators, differentiators, active and passivefilters. Universal Filters and their application

Current-to-voltage and voltage-to-current converter, analog-to-digital converter, digital-to-analog converter, voltage-to-frequency converter, frequency-to-voltage converter.

Switched capacitor filter, Phase locked loop, Schmitt trigger, automatic gain control, regulators, wave formgenerators, oscillators.

Case studies: bridge linearization, PLL design using divider and multipliers, regulator design with low voltagedropout, transmitter design and realization of controllers.

Text Books:

1. Sergio Franco, Design with operational amplifiers and analog integrated circuits, 4th edition Mc-Graw HillInc. 2014.
2. A.P. Malvino, Electronic Principles, Tata McGraw Hill Publications, 8th Edition, 2016
3. Wai-Kai-Chen, The circuits and filters Handbook, CRC press, 2nd Edition, 2003.
4. Gabel R.A. and Robert R.A., Signals and Linear Systems, John Wiley and Sons, 3rd Edition, 2009

Reference Books:

1. James M. Fiore, Op Amps and Linear Integrated Circuits – Concepts and Applications, Cengage LearningPvt, Ltd, 3rd Edition, 2016.
2. Behzad Razavi, Design of Analog CMOS Integrated circuits, Tata McGraw Hill Edition, 2006.
3. NPTEL - Lecture Series on Analog ICs, Analog circuits and system's by Prof. K. Radhakrishna Rao,Department of Electrical Engineering, I.I.T. Madras.

Course outcomes:

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

1.Understand the implications of the properties of systems and signals2.Design and simulate various analog signal conditioning circuits 3.Implement various analog signal conditioning circuits in real time 4.Trouble shoot analog signal conditioning circuits

ICPC18 - MICROPROCESSORS AND MICROCONTROLLERS

Course type: Programme Core (PC) ***Pre-requisites:*** ICPC14
No. of Credits: 3

Course Objectives:

1. To introduce the architecture of 8, 16 and 32-bit microprocessor and microcontroller.
2. To impart microcontroller programming skills in students.
3. To familiarize the students with data transfer and interrupt services.
4. To Familiarize the students with communication protocols for peripheral interfacing

Course Content:

Introduction to computer architecture and organization, Architecture of 8-bit, 16-bit, 32-bit and 64-bit microprocessors, CISC/RISC design philosophy, bus configurations, CPU module. Embedded system overview.

Introduction to embedded C and assembly language, instruction set of a typical 8-bit and 16-bit microprocessor,subroutines and stacks, energy efficient ultra-low power modes, programming exercises.

Timing diagrams, Memory families, Flash Vs FRAM, on-chip peripherals- working with IO ports, ADC, comparators, timers, PWM, Watchdog, Low power modes.

Architectures of 8 and 16-bit Microcontrollers, comparison, programming exercises, applications of energy efficientsystems.

Serial and parallel data transfer schemes, interrupts and interrupt service procedure. Internal peripherals of microcontrollers – SPI, I2C UART, USB and DNA. Interfacing with RTC, EEPROM and DAC.

Text Books:

1. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with the 80856th Edition, Penram International Publishing (India) pvt. Ltd.2013.
2. Douglas V. Hall, Microprocessors and Interfacing-Programming and Hardware, Mc Graw Hill,2nd Edition, 1999.
3. Kenneth J. Ayala, The 8051 Micro controller, Thomson Delmar Learning, 3rd Edition, 2004.
4. John H Davies, MSP430 Microcontroller Basics, Newnes, 1st Edition, 2010.

Reference Books:

1. Jonathan W Valvano, Embedded Microcomputer Systems: Real Time Interfacing, CENGAGE LearningCustom Publishing, 3rd Edition, 2010.

Course outcomes:

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

1. Understand the various functional blocks of microprocessor and microcontrollers.
2. Understand and write the assembly and C language programs.
3. Interface the peripherals with microprocessors and microcontrollers
4. Design and develop microcontroller-based applications

ICPC19 – CONTROL SYSTEMS - II

Course type: Programme Core (PC) ***Pre-requisites: -***
No. of Credits: 4

Course Objectives

1. To introduce about the system states and state-space modeling of dynamical systems.
2. To teach the advanced methods and techniques of linear system analysis and stability using Lyapunov theory.
3. To demonstrate how algebraic methods can be deployed in developing feedback controllers for a larger scale of systems.
4. To develop practical control systems using digital computers through data acquisition and computing.

Course Content

State-space Models – Review of vectors and matrices, Canonical Models from Differential Equations and Transfer Functions, Interconnection of subsystems.

Analysis of Linear State Equations – First order scalar differential equations, System modes and model decomposition, State Transition Matrix, Time-varying matrix case.

Lyapunov's stability theory for Linear Systems – Equilibrium points and stability concepts, Stability definitions, Linear system stability, The Direct method of Lyapunov, Use of Lyapunov's method in feedback design.

Controllability and Observability – Definitions, Controllability/Observability Criteria, Design of state feedback control systems, Full-order and Reduced-order Observer Design, Kalman canonical forms, Stabilizability and Detectability.

Digital Control Systems, Closed-loop Feedback Sampled-Data Systems, Stability Analysis, Implementation of Digital Controllers. One detailed case study of modern control theory.

Text Books:

1. Katsuhiko Ogata, Modern Control Engineering, PHI Learning Private Ltd, 5th Edition, 2010.
2. Franklin, G.F., David Powell, J., Emami-Naeini, A., Feedback Control of Dynamic Systems, Prentice Hall, 7th Edition, 2014.
3. Dorf, R.C., Bishop, R.H., Modern Control Systems, Prentice Hall, 13th Edition, 2016.
4. Brogan, W.L., Modern Control Theory, Prentice Hall, 3rd Edition, 1990.

Reference Books:

1. John J.D., Azzo Constantine, H. and Houpis Stuart, N Sheldon, Linear Control System Analysis and Design with MATLAB, CRC Taylorand Francis Reprint 2009.
2. I.J. Nagrath and M. Gopal, Control Systems Engineering, New Age International Publishers, 6th Edition, 2017.

3. William A. Wolovich, Automatic Control Systems, Oxford University Press, 1st Indian Edition 2010.

Course Outcomes

On completion of this course, the students will be,

1. Exposed to an appropriate modern paradigm for the study of larger scale multi-input-multi- output systems.
2. Able to use linear algebra and matrix theory in the analysis and design of practical control systems.
3. Able to determine the stability of systems using Lyapunov's theory.
4. Motivated to implement modern control systems using a digital computer.

ICPC20 - INDUSTRIAL INSTRUMENTATION

Course type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
3. Make the students how to select and maintain the performance of new technology flow instruments.
4. To make the students knowledgeable in the design, installation and troubleshooting of process instruments.

Course Content:

Temperature measurement: Introduction to temperature measurements, Thermocouple, Resistance Temperature Detector, Thermistor and its measuring circuits, Radiation pyrometers and thermal imaging.

Pressure measurement: Introduction, definition and units, Mechanical, Electro-mechanical and electronic pressure measuring instruments. Low pressure measurement, Transmitter definition types, I/P and P/I Converters.

Level measurement: Introduction, Differential pressure level detectors, Capacitance level sensor, Ultrasonic level detectors and Radar level transmitters and gauges.

Flow measurement: Introduction, definition and units, classification of flow meters, differential pressure and variable area flow meters, Positive displacement flow meters, Electro Magnetic flow meters.

Flow measurement: Hot wire anemometer, laser Doppler anemometer, ultrasonic, vortex and cross correlation flow meters, and measurement of mass flow rate.

Text Books:

1. Ernest.O. Doebelin and Dhanesh.N. Manik, Doebelin's Measurement Systems, McGraw Hill Education, 6th Edition, 2011.
2. B.G. Liptak, Process Measurement and Analysis, CRC Press, 4th Edition, 2003.
3. Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill, 3rd Edition, 2010.

Reference Books:

1. B.E. Noltingk, Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.
2. Douglas M. Considine, Process / Industrial Instruments and Controls Handbook, McGraw Hill, Singapore, 5th Edition, 1999.
3. Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I andVol II, GulfPublishing Company, Houston, 2001
4. Spitzer D. W., Industrial Flow measurement, ISA press, 3rd Edition, 2005.
5. Tony.R. Kuphaldt, Lessons in Industrial Instrumentation, Version 2.02, April 2014.
6. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd

Course outcomes:

On completion of this course, the students will be,

1. Familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
2. Able to explain the basic principles of measuring instruments used for measuring the four important variables.
3. Will be able to identify a suitable measuring instrument for an application.
4. Able to design signal condition and compensation circuits for temperature and pressure measuring instruments.
5. Able to trouble shoot and maintain the temperature, flow, pressure and level measuring device for a specific process.

ICPC21 - ELECTRICAL AND ELECTRONIC MEASUREMENTS

Course type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To give an overview of current, voltage and power measuring electrical, electronics and digital instruments.
2. To expose the students to the design of bridges for the measurement of resistance, capacitance and inductance.
3. To give an overview of test and measuring instruments.
4. To provide the working knowledge of various waveform generators, analyzers and display devices.

Course Content:

Electrical measurements: General features and Classification of electro mechanical instruments. Principles of Moving coil, moving iron, dynamometer type, rectifier type, thermal instruments. Extension of instrument range: shunt and multipliers, CT and PT.

Measurement of Power: Electrodynamic wattmeter’s, Low Power Factor (LPF) wattmeter, errors, calibration of wattmeter. Single and three phase power measurement, Hall effect wattmeter, thermal type wattmeter.

Measurement of resistance, inductance and capacitance: Low, high and precise resistance measurement, Megger, Ohmmeters, Classical AC bridges: Inductance and capacitance measurements. Detectors in bridge measurement, bridge screening, Wagner earth, transformer ratio bridges.

Electronic and digital measurements: Electronic voltmeter, current measurement with electronicinstruments, Digital voltmeter, Analog and digital multi-meters, Digital frequency meters. Digital LCR meter, Q-Meter, Digital wattmeter and energy meters.

DSO, MSO, Function generators, Signal generators, Waveform analyzers, Spectrum analyzers, Distortion analyzers, LED, LCD and Organic LED displays.

Text Books:

1. Golding's, Electrical Measurements and Measuring Instruments, 6th Edition, (Revised and Enlarged): WithSolved Examples and MCQ's (In M.K.S. Units), MedTech, Jan 2019.
2. Shawney A K, A course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Sons, Jan 2015.
3. David A. Bell, Electronic Instrumentation and Measurements, Oxford University Press India; 3rd Edition, 2013.
4. Prithwiraj Purkait, Budhaditya Biswas, Santanu Das, Chiranjib Koley, Electrical and Electronics Measurements and Instrumentation, by McGraw Hill Education (India) Private Limited, 2013

Reference Books:

1. H. S. Kalsi, Electronic Instrumentation, McGraw Hill Education; 3rd Edition, 2017.
2. Albert D. Helfrick, William D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, 1st Edition, Pearson, 2016.
3. Ernest O Doebelin and Dhanesh N Manik, Measurements systems Application and design, McGraw Hill publication, 5th Edition, 2015.

Course outcomes:

On completion of this course, the students will be,

1. Familiar with various measuring instruments (ammeters, voltmeters, wattmeters, energy meters, extension of meters, current and voltage transformers) used to measure electrical quantities.
2. Able to design suitable DC and AC bridges for the measurement of R, L, C and Frequency measurement.
3. Able to suggest the kind of instrument suitable for typical measurements.
4. Able to use the test and measuring instruments effectively.

ICPC22 - PROCESS CONTROL

Course type: Programme Core (PC) ***Pre-requisites:*** ICPC16
No. of Credits: 3

Course Objectives:

1. To introduce the terminology and concepts associated with Process control domain.
2. To impart knowledge in the design of control systems and PID controller tuning for processes.
3. To familiarize the students with characteristics, selection, sizing of control valves.
4. To elaborate different types of control schemes such as cascade control, feed forward control and Model Based control schemes.

Course Content:

Process Control System: Terms and objectives, piping and Instrumentation diagram, instrument terms and symbols. Regulatory and servo control, classification of variables. Process characteristics: Process equation, degrees of freedom, modeling of simple system, Self-regulating processes, interacting and non- interacting processes, Process lag, load disturbance and their effect on processes.

Controller modes: Basic control action, two position, multi-position, floating control modes. Continuous controller modes: proportional, integral, derivative. Composite controller modes: P-I, P-D, P-I-D, Integral wind-up and prevention. Auto/Manual transfer, Bumpless transfer. Response of controllers for different test inputs. Selection of control modes for processes like level, pressure, temperature and flow.

Final control elements: Pneumatic and electrical actuators, Valve positioners. Pneumatic and electrical dampers, Control valves types, construction details, various plug characteristics. Energy efficient valves - Valve sizing - selection of control valves. Inherent and installed valve characteristics. Fail-safe operation, Cavitation and flashing in control valves, Instrument air supply specifications.

Controller tuning Methods: Evaluation criteria - IAE, ISE, ITAE. Process reaction curve method, continuous oscillation method, damped oscillation method. Auto tuning. Closed loop response of I and II order systems, with and without valve, measuring element dynamics.

Advanced control system: Cascade control, ratio control, feed forward control. Over-ride, split range and selective control. Multivariable process control, interaction of control loops. Introduction to Dynamic Matrix Control. Case Studies: Distillation column, boiler drum level control and chemical reactor control.

Text Books

1. G. Stephanopoulos, Chemical Process Control-An Introduction to Theory and Practice. Prentice Hall of India, New Delhi, 3rd Edition,2008.
2. D.R. Coughanowr, Steven E LeBlanc, Process Systems Analysis and Control, McGraw Hill, Singapore, 3rd Edition,2009.
3. B.W. Bequette, Process Control Modeling, Design and Simulation. Prentice Hall of India, New Delhi,2004.

4. William C. Dunn, Introduction to Instrumentation, Sensors, and Process Control, Artech House ublishers, 2005.

Reference Books

1. C.A. Smith and A.B Corripio., Principles and Practice of Automatic Process Control, John Wiley and Sons, New York, 3rd Edition2005.
2. Paul W. Murril, Fundamentals of Process Control Theory, ISA press, New York, 3rd Edition, 2000.
3. Bela G. Liptak, Instrument Engineers' Handbook, Volume II: Process Control and Optimization, CRC Press, 4th Edition,2005.
4. D.E. Seborg, T.E. Edgar, D.A. Mellichamp. Process Dynamics and Control, Wiley India Pvt. Ltd., Fourth Edition.2016.
5. Wolfgang Altmann, Practical Process Control for Engineers and Technicians , Elsevier/Newnes publishing, 2009
6. Donald P. Eckman, Automatic Process Control, Wiley India Pvt Ltd , 2009.

Course outcomes:

On completion of this course, the students will be able

1. To understand technical terms and concepts associated with process control domain.
2. To build models using first principles approach as well as analyze models.
3. To design, tune and implement PID Controllers to achieve desired performance for various processes
4. To analyze the systems and implement control schemes for various processes.
5. To comprehend on advanced process control strategies.

ICPC23 - BIOMEDICAL INSTRUMENTATION

Course Type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

The course introduces the human physiological system with respect to medical instrumentation and its design and the instrumentation for measuring and analyzing the physiological parameters.

1. To educate the students on the different medical instruments.
2. To familiarize the students with the analysis and design of instruments to measure bio-signals like ECG, EEG, EMG, etc.
3. To have a basic knowledge in therapeutic devices
4. To introduce about the clinical laboratory instruments and familiar about electrical safety.

Course Content:

Electro physiology**:** Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, electrode theory, bipolar and uni-polar electrodes, surface electrodes, needle electrode and microelectrode, physiological transducers-selection criteria and its application.

Bioelectric potential and cardiovascular measurement**s**: ECG recording system, Heart sound measurement - stethoscope, phonocardiograph (PCG), Foetal monitor-ECG- phonocardiography, vector cardiograph, cardiac arrhythmia's monitoring system. EMG, EEG - Evoked potential response, ERG and EOG recording system. Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and direct measurement techniques.

Clinical Laboratory Equipment**:** Chemical tests in clinical laboratory, Spectrophotometry and its type of instrument, Automated Biochemical Analysis System, Flame photometer. Blood gas analyzer, Acid – base balance, Blood, pH measurement, blood pCO2, blood pO2, Intra –arterial blood gas analyzers, Blood cell counters- types of blood cells, - methods of cell counting -coulter counter- Automatic recognition and differential blood cell counting.

Respiratory and pulmonary measurements: Physiology of respiratory system, respiratory rate measurement-artificial respirator- oximeter, pulmonary function measurements–spirometer–photo plethysmography and body plethysmography. Principal and techniques of impedance pneumography, Apnea monitor.

Electrical safety: Sources of electrical hazards in medical environment and safety techniques for checking safety parameters of biomedical equipment.

Text Books:

1. John G. Webster, John W Clark, jr, Medical Instrumentation Application and Design, 4^{th} Edition,John Wiley and sons, New York, 2010
2. Arthur Guyton, John E. Hall, Text Book of Medical Physiology, 12^{th} Edition, Elsevier Saunders, 2011.
3. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall of India, New Delhi, 2014.
4. Jerry. L.Prince, Jonathan M. Links, Medical Imaging Signals and Systems, 2^{nd}Edition, Pearson Prentice Hall, 2015.
5. Shakti Chatterjee and Aubert Miller, Biomedical Instrumentation Systems, CENGAGE Learning publishing, 2016.

Reference Books:

1. Onkar N. Pandey and Rakesh Kumar, Bio-Medical Electronics and Instrumentation, Katson Books, 2011
2. Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology ,4^{th}Edition, Pearson publishing, 2013.
3. R.S. Khandpur, Hand Book of Biomedical Instrumentation, 3^{rd} edition, McGraw Hill Education (India) Private Limited, 2014.
4. Andrew G. Webb, Principles of Biomedical Instrumentation, Cambridge University Press, 2018.
5. Cromwell, Biomedical Instrumentation and Measurement, 2nd Edition, Pearson India 2015.

Course Outcomes:

On completion of this course the students will be,

1. To understand, design and evaluate systems and devices that can measure, test and/or acquire bio-signal information from the human body.
2. Familiar with patient monitoring equipment used in hospitals.
3. Ability to explain the medical diagnostic and therapeutic techniques
4. Familiar with various clinical laboratory instruments used for diagnosis.

ICPC24 - ANALYTICAL INSTRUMENTATION

Course type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To teach the students about the analysis of materials which is an important requirement of process control and quality control in industry
2. To expose the students to principles of various analytical methods.
3. To impart knowledge on various spectroscopic instruments used in the analysis of materials
4. To introduce the concept of analytical instruments used in drug and pharmaceutical lab
5. To introduce different analytical instruments used in environmental pollution monitoring

Course Content:

Electromagnetic radiation and its interaction with matter – Beer's law – Spectral methods of analysis – Absorption spectroscopy – Radiation sources – Monochromators – Filters – Prisms – Diffraction gratings – Detectors – Choice of solvents. UV-Visible spectrometers – single-beam and double-beam instruments.

Infrared spectrophotometer – IR sources – Cells – detectors – sample preparation. Analysis using Attenuated Total Reflectance (ATR). Atomic absorption spectrometry (AAS) – Wavelength choice – Sources – Cells – Detectors. Flame emission spectrometry. Atomic fluorescence spectrometry.

X-ray spectroscopy – X-ray absorption methods – X-ray fluorescence methods – X-ray diffraction. Radioactive measurement – Units of radioactivity – Application of radio-nuclides in analysis – Radioactivity detectors. Nuclear magnetic Resonance (NMR) spectroscopy – Basic principles – Continuous-wave NMR spectrometer – Pulsed Fourier Transform NMR spectrometer – NMR applications.

Sampling – Sample collection for gas, liquid, and solid analysis. pH measurement – Basic principles –Ion selective electrodes – Glass and reference electrodes – pH meter and its calibration. Electrical conductivity measurement – Measuring circuit – Water and steam purity measurement using electrical conductivity. Oxygen measurement – Paramagnetic oxygen analyzers – Ceramic electrode for high temperature oxygen measurement – Dissolved oxygen measurement.

Flue gas analysis for pollution control – Measurement of CO, carbon di-oxide, NOX and SOX, dust and smoke measurement. Chromatography – Basic principles of liquid and gas chromatography – Column details – Detectors for chromatography – Thermal conductivity detector – Flame ionization detector – Flame photometric detector – Electron capture detector – Effect of temperature programming – High pressure liquid chromatography (HPLC).

Text Books:

1. Braun, Robert D., Introduction to Instrumental Analysis, Pharma Book Syndicate, Hyderabad, 2nd Edition, 2012.
2. Ewing, G.W., Instrumental Methods of Analysis, McGraw Hill, Singapore, 5th Edition, 1992.
3. Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.

Reference Books:

1. Bela G. Liptak, Instrument Engineers' Handbook, Volume One: Process measurement and analysis, CRC Press, 4th Edition, 2003.
2. Considine, D.M. Process/Industrial Instruments and Controls Handbook, McGraw Hill, Singapore, 4th Edition, 1993.
3. Sherman, R.E. and Rhodes L.J., Analytical Instrumentation, ISA Press, New York, 1996.
4. Khandpur R.S, Handbook of Analytical Instruments, Tata McGraw Hills, 2nd Edn.2006.

Course outcomes:

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

1. Appreciate the relevance of material sampling and analysis in process control and quality control in industry.
2. Understand the physical principles behind the various widely used analytical methods in the industry.
3. Understand the important components and concepts of various spectroscopic instruments and instruments used in drug and pharmaceutical lab and pollution monitoring.
4. Select an appropriate analytical instrument for an industrial requirement.

ICPC25 - LOGIC AND DISTRIBUTED CONTROL SYSTEMS

Course type: Programme Core (PC) **Pre-requisites:** -
No. of Credits: 3

Course Objectives:

1. To introduce the importance of process automation techniques.
2. To impart knowledge in PLC based programming.
3. To introduce distributed control system and different communication protocols.
4. To have adequate information with respect to interfaces used in DCS

Course Content:

Review of PC based control design for process automation: Functional Block diagram of Computer control of process - Mathematical representation – Sampling Consideration- Data Acquisition system and SCADA, Hybrid, Direct Digital Control System, Distributed Control System architecture and Comparison with respect to different performance attributes.

Programmable logic controller (PLC) basics: Definition, overview of PLC systems, Block diagram of PLC. General PLC programming procedures: ON/OFF instruction, Timer instruction sets, Counter Instruction sets -Design, development and simulation of PLC programming using above instruction sets for simple applications.

PLC Data manipulation instruction - Arithmetic and comparison instruction- Skip, Master Control Reset (MCR) and Zone Control Last state (ZCL) instruction – PID and other important instruction set. PLC Installation, troubleshooting and maintenance. Design of alarm and interlocks, networking of PLC – Case studies using above instruction sets.

Distributed Control System: Local Control Unit (LCU) architecture - Comparison of different LCU architectures – LCU Process Interfacing Issues: - Block diagram, Overview of different LCU security design approaches, secure control output design, Manual and redundant backup designs.

LCU communication Facilities - Communication system requirements – Architectural Issues – Operator Interfaces – Engineering Interfaces. Development of Field Control Unit (FCU) diagram for simple control applications. Introduction to HART and Field bus protocol. Interfacing Smart field devices (wired and wireless) with DCS controller. Introduction to Object Linking and Embedding (OLE) for Process Control, Automation in the cloud with case studies.

Text Books:

1. John W. Webb and Ronald A. Reis, Programmable Logic Controllers - Principles and Applications, Prentice Hall Inc., New Jersey, 5th Edition,2003.
2. Lukcas M.P Distributed Control Systems, Van Nostrand Reinhold Co., New York,1986.
3. Frank D. Petruzella, Programmable Logic Controllers, McGraw Hill, New York, 5th Edition, 2016.

Reference Books

1. Deshpande P. Band Ash R.H., Elements of Process Control Applications, ISA Press, New York 1995.
2. Curtis D. Johnson, Process Control Instrumentation Technology, Pearson New International, 8th Edition,2013.
3. Krishna Kant, Computer-based Industrial Control, Prentice Hall, NewDelhi,2nd Edition,2011.
4. F.D. Petruzella, Programmable Logic Controllers, Tata Mc-Graw Hill, 3rd Edition,2010
5. D. Popovic and V.P. Bhatkar, Distributed computer control for industrial Automation, Marcel Dekker, Inc., New York, 1990.

Course outcomes:

On completion of this course, the students will be

1. Familiar with process automation technologies.
2. Able to design and develop a PLC ladder programming for simple process applications.
3. Able to apply different security design approaches, engineering and operator interface issues for designing of Distributed Control System.
4. Familiar with latest communication technologies like HART and Field bus protocol.

Essential Programme Laboratory Requirement (LR) Courses

ICLR10 – THERMODYNAMICS AND FLUID MECHANICS LABORATORY

Course Type: Essential Laboratory Requirement (LR)
No. of Credits: 2

Course Objectives:

1. To familiarize with the principles of thermal energy and its transformation to mechanical energy.
2. To introduce about thermodynamics - concepts and properties, first and second law.
3. To provide a working knowledge of thermodynamics and fluid mechanics.

List of Experiments:

Thermodynamics

1. Performance test on Petrol and Diesel Engines with Mechanical and Electrical Dynamometers
2. Morse test on multi-cylinder petrol engine
3. Determination of volumetric efficiency on Diesel engine and Two stage reciprocating Air compressor
4. COP in compression refrigerator cycle
5. Test on Air conditioning system
6. Viscosity index of lubricant
7. Study of steam power plant

Fluid Mechanics

1. Determination of pipe friction
2. Calibration of flow meters – Venturi meter and Orifice meter
3. Determination of discharge coefficients for notches
4. Determination of minor losses
5. Centrifugal pump
6. Submersible pump
7. Jet pump
8. Gear pump
9. Screw pump

Reference Books:

1. Zemansky, Heat and Thermodynamics, McGraw Hill, New York, 7th Edition 1997.
2. Ojha C.S.P., Berndtsson R., Chandramouli P.N., Fluid Mechanics and Machinery, Oxford University Press, 2010.

Course Outcomes:

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

1. Understand heat, work, internal energy, and 1st and 2nd law of thermodynamics.
2. Carryout dimensional analysis, fluid statics and dynamics.
3. Demonstrate fluid mechanics fundamentals, including concepts of mass and momentum conservation.
4. Apply the Bernoulli equation and control volume analysis to solve problems in fluid mechanics.

ICLR11 – CIRCUITS AND DIGITAL LABORATORY

Course Type: Essential Laboratory Requirement (LR)
No. of Credits: 2

Course Objectives:

1. To introduce to the design of passive, bilateral electrical circuits.
2. To impart knowledge in network analysis and realization.
3. To impart knowledge in design and verification of combinational and sequential logic circuits.

List of Experiments:

1. Verification of Electrical Circuit laws and network theorems.
2. Time Response of RL, RC and RLC circuits.
3. Frequency Response of RL, RC and RLC circuits, resonance.
4. A.C. circuits and Network realization.
5. Design and verification of combinational logic circuits.
6. Design and verification of sequential logic circuits.

Reference Books:

1. Hayt, W.H, Kemmerly J.E. and Durbin, Engineering Circuit Analysis, McGraw HillPublications, 8th edition, 2013.
2. Ramakalyan, A., Linear Circuits: Analysis and Synthesis, Oxford Univ. Press, 2005.
3. Van Valkenburg, Network Analysis, Prentice Hall, 3rd Edition, 2006
4. Van Valkenburg, M.E., Introduction to Modern Network Synthesis, Wiley, 1960.
5. M.M. Mano, Digital Logic and Computer Design, Pearson, 4th Edition, 2014.

Course Outcomes:

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

1. Design and analyze electrical circuits based on circuit laws and network theorems.
2. Analyze the time response and frequency response of RL, RC and RLC circuits.
3. Design and verify sequential and combinational logic circuits.

ICLR12 – SENSORS AND TRANSDUCERS LABORATORY

Course Type: Essential Laboratory Requirement (LR)
No. of Credits: 2

Course Objectives:

1. To familiarize the students to the basic principles of various transducers.
2. To impart knowledge in static and dynamic characteristics of sensors.
3. To impart knowledge in the design of signal conditioning circuits for transducers.

List of Experiments:

1. Characteristics of (Resistive and Thermo emf) temperature sensor
2. Characteristics of Piezoelectric measurement system
3. Measurement of displacement using LVDT
4. Characteristics of Hall effect sensor
5. Measurement of strain using strain gauges
6. Measurement of torque using Strain gauges
7. Measurement using proximity sensors
8. Characteristics of capacitive measurement systems
9. Loading effects of Potentiometer
10. Design of Opto-coupler using photoelectric transducers
11. Characteristics of Micro pressure and Micro accelerometer sensing device
12. Study of speed measuring devices and Gyroscope

Reference Books:

1. John P. Bentley, Principles of Measurement Systems, Pearson Education, 4th Edition, 2005.
2. Ernest.O. Doebelin and Dhanesh.N. Manik, Doebelin's Measurement Systems, McGraw Hill Education, 6th Edition, 2011.

Course Outcomes:

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

1. Analyze the static characteristics of different measurement systems.
2. Design signal conditioning circuits for transducers.
3. Formulate the design specification of transducer for a given application.

ICLR13 – ANALOG SIGNAL PROCESSING LABORATORY

Course type: Essential Laboratory Requirement (LR)
No. of Credits: 2

Course Objectives:

1. To introduce system level design.
2. To impart knowledge in design and test Op-amp and other ICs based circuits.
3. To familiarize the students in simulation tools and evaluation boards available for analog signal processing.

List of experiments:

1. Design of amplifiers using various modes and its implementation issues
2. Filter design using various methodologies for different set of specifications
3. Sensor linearization and bridge linearization using op-amps
4. Design of waveform generators using op-amp
5. PLL design
6. Regulator design
7. Analog to digital conversion and digital to analog conversion
8. Regenerative feedback circuit design - Schmitt trigger and Multivibrator
9. Transmitter design

Text Books:

1. Sergio Franco, Design with operational amplifiers and analog integrated circuits, 4th edition Mc-Graw Hill Inc. 2014.
2. Wai-Kai-Chen. The circuits and filters Handbook, CRC press, 2nd edition, 2003.
3. Arie F. Arbel, Analog Signal Processing and Instrumentation, Cambridge University press, 1980.

Course Outcomes:

On completion of this lab, the students will be able to,
1. Design analog and digital system level circuit.
2. Simulate and validate analog IC circuits using simulation software.
3. Apply this basic IC circuit design concepts for application

ICLR14 – CONTROL ENGINEERING LABORATORY

Course Type: Essential Laboratory Requirement (LR)
No. of Credits: 2

Course Objectives:

1. To impart knowledge on analysis and design of control system in time and frequency domain.
2. To impart knowledge in classical control and state space-based control system design.
3. To familiarize the students with MATLAB Real-time programming to collect and process data.

List of Experiments:

1. Time response characteristics of a second order system.
2. Frequency response characteristics of a second order system.
3. Constant gain compensation in time and frequency domain.
4. Compensating Networks - Characteristics
5. Design of compensation networks - Lead, Lag, Lead-lag
6. Design of state feedback controller.
7. Observer design - full order and reduced order.
8. Real time control of AC/DC servo system
9. Real Time control of 2 DOF Helicopter control
10. Real Time vibration control of cantilever beam at resonance with piezoelectric sensing and actuation
11. Real time control of 3DOF GYRO
12. Real time control of Inverted Pendulum

Reference Books:

1. Dorf, R.C., and Bishop, R.H., Modern Control Systems, 12th Edition, Prentice Hall,2010.
2. Daniel H. Sheingold, Transducer Interfacing Handbook – A Guide to Analog Signal Conditioning, Analog Devices Inc. 1980.

Course Outcomes:

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

1. Design control systems in both classical and modern techniques.
2. Design and implement controllers to regulate and control various systems.
3. Design full order and reduced order state observer.

ICLR15 – MICROPROCESSORS AND MICROCONTROLLERS LABORATORY

Course Type: Essential Laboratory Requirement (LR)
No. of Credits: 2

Course Objectives:

1. To provide practical experience with 16bit/32bit microcontrollers/microprocessors-based circuits and their interfaces.
2. To enable the students to program, simulate and test various devices using a C language-based compiler.
3. To provide a platform for the students to do multidisciplinary projects.

List of Experiments:

1. Familiarization with the given micro-controller board and its assembler.
2. Basic I/O operations using switches, LEDs and LCD.
3. Programming exercises using interrupts and timers
4. ADC and DAC Interfacing.
5. I/O interfaces- parallel, Serial, SPI, I2C data Transmission.
6. Real time clock and memory interfacing with microcontroller
7. Interfacing microcontroller with stepper motor
8. Building microcontroller-based system for various applications

Reference Books:

1. Kenneth J. Ayala, The 8051 Micro controller, Thomson Delmar Learning, 3rd Edition, 2004.
2. Andrew N. Sloss, Dominic Symes, and Chris Wright, ARM System Developer's Guide:
3. Designing and Optimizing System Software, Morgan Kaufmann Publishers, 2004.
4. Joseph Yiu, The Definitive guide to ARM Cortex-M3 and Cortex-M4 Processors PB, Elsevier India Pvt Ltd, 3rd Edition, 2014
5. John H. Davies, MSP430 microcontroller basics, Newnes, 1st Edition, 2010.
6. C.P. Ravikumar, MSP430 Microcontroller in Embedded system projects, Elite publishing house Pvt. Ltd., 2012.

Course Outcomes:

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

1. Program microprocessor/ micro-controller using a C language-based compiler.
2. Understand the key concepts of embedded systems like IO, timers, interrupts, interaction with peripheral devices
3. Design and develop embedded system and will be familiar with the debugging techniques.

ICLR16 – INSTRUMENTATION LABORATORY

Course Type: Essential Laboratory Requirement (LR)
No. of Credits: 2

Course Objectives:

1. To familiarize the students with different signal conditioning circuits for temperature and pressure measuring transducer.
2. To familiarize the students to the calibration practices used in industries.
3. To impart knowledge in the transmitter design.

List of Experiments:

1. Design of temperature transmitter using RTD.
2. Design of cold junction compensation circuit for Thermocouple.
3. Design of IC temperature transmitters.
4. Design of Linearization circuit for thermistor.
5. Study of zero elevation and suppression in differential pressure transmitter
6. Performance evaluation of pressure gauges using Dead weight tester.
7. Measurement of level using differential pressure transmitter.
8. Design of alarms and annunciators for process variable measurements.
9. Design of pressure/force transmitter

Reference Books:

1. Doebelin E.O, Measurement Systems: Application and Design, McGraw Hill, 5th Edition, 2004.
2. Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill, 3rd Edition, 2010.
3. Roy D. Choudary and Shail Jain, Linear Integrated Circuits, New Age International, 2010.

Course Outcomes:

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

1. Suggest a suitable temperature sensor for an application.
2. Design the required conversion and manipulation circuits for temperature and pressure measurement systems.
3. Evaluate various temperature and pressure measuring sensors.

ICLR17 – INDUSTRIAL AUTOMATION AND PROCESS CONTROL LABORATORY

Course Type: Essential Laboratory Requirement (LR)
No. of Credits: 2

Course Objectives:

1. To impart practical knowledge in PC based data acquisition, analysis and control ofdifferent process trainers.
2. To teach the industrial automation concept and programming techniques.
3. To familiarize the process modelling and control using simulation tools.

List of Experiments:

1. Identification of FOPDT and SOPDT process using time domain and frequencydomain techniques.
2. Design of different PID controller for FOPDT and SOPDT process using differentstandard technique and evaluate qualitative and quantitative performance.
3. Study of Different Process trainers.
4. Design and Verification of Combinational and Sequential Circuits Using PLC.
5. Design of PID Controller for a Level Process/Temperature/Flow/Pressure processstations and evaluate servo/regulatory responses.
6. Study the effect of different PID Controller Parameters using real time process trainer.
7. Pressure to Current and Current to Pressure Convertor using real time process trainer.
8. Design of Timer and Counter Using PLC.
9. Design of PLC programming for practical applications.
10. Design of Cascade and Feed forward-feedback Controller using simulation software.
11. Verification of Control Valve Characteristics using pneumatic and electronic controlvalue trainer.
12. Development of PandI design using Distributed control system (DCS).

Reference Books:

1. G. Stephanopoulos, Chemical Process Control-An Introduction to Theory andPractice Prentice Hall of India, New Delhi, 2^{nd} Edition, 2005.
2. D.R. Coughanowr, Process Systems Analysis and Control, McGraw Hill, Singapore,2^{nd} Edition, 1991.
3. B.W. Bequette, Process Control Modeling, Design and Simulation, Prentice Hall ofIndia, New Delhi, 2004.

Course Outcomes:

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

1. Design PID controller and tune the same for various process.
2. Implement sequential logic control using PLC for a required application.
3. Use the simulation tools for the design of controller for various process.

PROGRAMME ELECTIVE (PE) COURSES

ICPE10- INSTRUMENTATION PRACTICES IN INDUSTRIES

Course type: Programme Elective (PE) ***Pre-requisites:*** ICPC20
No. of Credits: 3

Course Objectives:

1. To expose the students to requirement of standards and calibration techniques, safety mechanisms in instruments used in process industries.
2. To impart knowledge about EMI and EMC problems in industrial measurements.
3. To make the students to draw the specification of the industrial instruments and prepare the instrumentation project documents.

Course Content:

Selection and Application: Selection and application of temperature, pressure, flow and level measuring instruments.

Standards and Calibration: Introduction to standards and calibration, calibration of temperature, pressure and flow measuring devices. Introduction to ISO, IEC and API standards pertaining to temperature, pressure and flow instrumentation.

EMI and EMC: Introduction, interference coupling mechanism, basics of circuit layout and grounding, concepts of interfaces, filtering and shielding.

Safety: Introduction, electrical hazards, hazardous areas and classification, non-hazardous areas,enclosures-NEMA types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety.

Specifications: Specification of instruments, preparation of project documentation, process flow sheet, instrument index sheet, instrument specifications sheet, panel drawing and specifications, instrument specifications. Project procedure, schedules, vendor drawing, tender documentation, selection of measurement method and control panels.

Text Books:

1. Noltingk B.E., Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.
2. Liptak B.G, Process Measurement and Analysis, Chilton Book Company, Radnor, Pennsylvania, 4th Edition, 2003.
3. Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I andVol II, GulfPublishing Company, Houston, 2001
4. Spitzer D. W., Industrial Flow measurement, ISA press, 3rd Edition, 2005.

Reference Books:

1. Patranabis D., Principles of Industrial Instrumentation, Tata McGraw Hill Publishing Company Ltd, 3rd Edition, 2010.
2. Lawrence D. Goettsche, Maintenance of Instruments and Systems, International society of automation, 2nd Edition, 2005.
3. Henry W.Ott, Electromagnetic Compatibility Engineering, A John Wiley and Sons, INC., Publication, 2009.

Course outcomes:

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

1. Select the appropriate instrument for a given process measurement problem.
2. Identify and classify the use of instruments in process industries according to the safety practices in industry.
3. Prepare instruments specification and understand the procedure and process involved in project documentation.
4. Understand and implement the safety standards and preventive action in industries.

ICPE11 - OPTICAL INSTRUMENTATION

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To expose the students on the basics of optical sources and detectors, optical fiber and fiber optic sensors.
2. To impart knowledge on the characteristics of optical sources and detectors.
3. To provide adequate knowledge about the optical fiber and their characteristics.
4. To introduce about the Industrial applications of fiber optic sensors and lasers.

Course Content:

Introduction: Characteristics of optical radiation, luminescence.

Optoelectronic sources:
LED – LED power and efficiency, structures- planar, dome, ELED, SLED, super luminescent LEDS, characteristics and applications.
LASERS – structures- gain guided and index guided lasers, types- semiconductor- homo and hetero junction lasers. Non-semiconductor lasers - gas, liquid and solid. Single frequency Lasers, characteristics, Q switching and mode locking, cavity dumping.

Optoelectronic detectors: General characteristics of photodetectors, Photodiode, junction photodiodes – heterojunction diode and PIN diode, APD, Special detectors- Schottky barrier diode, photo- transistor and photo-thyristor, solar cells.

Optical fiber- Fundamentals, types, transmission characteristics. Fibers splicing, connector and couplers. Optocouplers and optrodes.

Industrial applications – Fiber optic sensors -temperature, pressure, flow and level measurement.
LASERS – Distance, length, velocity, acceleration, current and voltage measurements. Material processing: Laser heating, melting, scribing, splicing, welding and trimming of materials, removal and vaporization, calculation of power requirements. Laser gyroscope.

Text Books:

1. Djafar.K. Mynbaev, Lowell. Scheiner, Fiber-Optic Communications Technology, Pearson Education Pvt. Ltd., 1st Edition, 2008.
2. John M Senior, Optical Fiber Communications: Principles and Practice, 3rd Edition, 2010.
3. Eric Udd, William B., and Spillman, Jr., Fiber Optic Sensors: An Introduction for Engineers and Scientists , John Wiley and Sons, 2011
4. R.P. Khare, Fiber optics and optoelectronics, Oxford University Press,2016

Reference Books:

1. Wilson and Hawkes, Opto Electronics - An Introduction, Prentice Hall, New Delhi, 3rd Edition, 2003.
2. Fukuda, Optical Semiconductor Devices, John Wiley, 2005.
3. Safa Kasap, Optoelectronics and Photonics: Principles and Practices: International Edition 2ndedition, 2013
4. Bhattacharya Pallab, Semiconductor Optoelectronic Devices, Pearson Education; 2nd Edition 2017
5. John Wilson and John Hawkes, Optoelectronics, Pearson India,2018

Course Outcomes:

On completion of the course the students will be,

1. Familiar with the fundamental principles of various types of optical sources, characteristics and its applications.
2. Able to understand the operation of different types of optical detectors and its limitations in industrial use.
3. Apply the gained knowledge on optical fibers for its use as communication medium in industrial use.
4. Knowledgeable on fiber-optical components and systems and its industrial applications.

ICPE12 – MEASUREMENT DATA ANALYSIS

Course Type: Programme Elective (PE) ***Pre-requisites*:** -
No of credit: 3

Course Objectives:

1. To give basic information about measuring instruments
2. To expose the students about the Statistical methods for estimating errors and uncertainties of real measurements:
3. To introduce the fundamental techniques of measurement for data analysis
4. To apply different measurement techniques that are performed in industry, commerce and experimental research for determination of parameters

Course Content:

General information about measurements, measuring instruments and their properties.

Statistical methods for Experimental Data Processing: Estimation of the parameters, Construction of confidence intervals, Methods for testing Hypotheses and sample homogeneity, Trends in applied statistics and experimental data processing.

Direct measurements: Method for calculating the errors and uncertainties, Methods for combining systematic and random errors.

Indirect measurements: Correlation coefficient and its calculation, the method of reduction, method of transformation, errors and uncertainty of indirect measurement. Examples of measurements and measurement data processing.

Combined Measurements:
Method of least squares, linearization of nonlinear conditional equations, and determination of the parameters in formulas from empirical data and construction of calibration curves. Combining the results of measurements. Calculation of the errors of measuring instruments.

Text Books:

1. Semyon G. Rabinovich, Measurement Errors and Uncertainties – Theory and Practice, Springer Publication, 3rd Edition, 2010
2. L. Kirkup, R. B. Frenkel, An Introduction to Uncertainty in Measurement: Using the GUM (Guide to the Expression of Uncertainty in Measurement), Cambridge University Press,2010
3. S.V. Gupta, Measurement Uncertainties: Physical Parameters and Calibration of Instruments, Springer, 2012.
4. Ernest O Doebelin and Dhanesh N Manik, Measurements systems Application and design, McGraw Hill publication, 5th Edition, 2015.

Reference Books:

1. Julius S. Bendat, Allan G. Piersol, Random Data: Analysis and Measurement Procedures, 4th Edition, Wiley, 2010.
2. Ifan Hughes and Thomas Hase, Measurements and Their Uncertainties: A Practical Guide to Modern Error Analysis, Oxford University Press, 2010.
3. Patrick F. Dunn, Measurement, Data Analysis, and Sensor Fundamentals for Engineering and Science., CRC Press , 2011

Course Outcomes:

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

1. Estimate measurement inaccuracies.
2. Evaluate the measurement system based on its quality and cost.
3. Acquire both theoretical knowledge and practical skills in working with measurement data.
4. Design and conduct experiments to analyze and interpret the data and generate reports.

ICPE13 - MICRO ELECTRO MECHANICAL SYSTEMS

Course Type: Programme Elective (PE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives

1. To introduce the fundamental concepts of MEMS and Micro systems and their relevance to current scientific needs.
2. To introduce the state-of-art micromachining techniques including surface micromachining, bulk micromachining, and related methods.
3. To make the students knowledgeable in the design concepts of micro sensors and micro actuators.
4. To introduce the challenges and limitations in the design of MEMS devices
5. To make the students knowledgeable in computer aided design tools for modeling MEMS device.

Course Content:

Introduction, emergence, MEMS application, scaling issues, materials for MEMS, Thin film deposition, lithographyand etching.

Bulk micro machining, surface micro machining and LIGA process.

MEMS devices, Engineering Mechanics for Micro System Design – static bending of thin plates, Mechanicalvibrational analysis, Thermomechanical analysis, fracture mechanics analysis, Thin film mechanics.

Theory and design: Micro Pressure Sensor, micro accelerometer – capacitive and piezoresistive, micro actuator.

Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

Text Books:

1. Tai Ran Hsu, MEMS and Microsystem Design and Manufacture, Tata McGraw Hill, New Delhi 2002.
2. Marc Madou, Fundamentals of Micro fabrication, CRC Press, 2nd Edition, 2002.
3. Julian W. Gardner and Vijay K. Varadan, Microsensors, MEMS, and Smart Devices, John Wiley and SonsLtd, 1st Edition, reprinted 2007.

Reference Books:

1. Elwenspoek, Miko, Wiegerink, R, Mechanical Microsensors, Springer-Verlag Berlin Heidelberg GmbH, 1stEdition, 2001.
2. Simon M. Sze, Semiconductor Sensors, John Wiley and Sons. Inc, 1st Edition, 2008.
3. Chang Liu, Foundations of MEMS, Pearson Educational limited, 2nd Edition, 2011.
4. Stephen D. Senturia., Microsystem Design , Kluwer Academic Publishers, 2001.
5. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, and V. K. Aatre., Micro and SmartSystems, Wiley-India, 2010.

Course Outcomes:

On completion of this course the students will be,

1. Able to understand the fundamental principles behind the working of micro devices/ systems and theirapplications.
2. Able to knowledgeable in the standard micro fabrication techniques.
3. Able to identify micro sensors and actuators for a specific application.
4. Able to do acquire skills in computer aided design tools for modeling and simulating MEMS devices.

ICPE14 - AUTOMOTIVE INSTRUMENTATION AND CONTROL

Course type: Programme Elective (PE) ***Pre-requisites*:-**
No. of Credits: 3

Course Objectives:

1. To impart knowledge on automobile system, its subsystems and components.
2. To expose the students to the concepts of various sensors used in automobile systems.
3. To teach the basic and advanced controls in automotive systems.
4. To impart knowledge about the electronics and software involved in automotive systems.

Course Content:

Automobile Fundamentals:

Introduction, Electronics in automotive and its evolution, Automotive physical configuration, Engine block, Cylinder head, Piton, Crankshaft, Camshaft, Connecting rod, Valve, 4-stroke cycle, Engine control,Ignition system, Spark plug, High voltage circuit and distribution, Spark pulse generation, Ignition timing, Drivetrain, Transmission, Drive shaft, Differential, Suspension, Brakes, Steering system.

Electronic engine control:

Motivation, Exhaust emission, Fuel economy, Concept of electronic engine control, Performance parameters and variables, Torque, Power, BSFC, Fuel consumption, Efficiency, Calibration, Engine mapping, Effect of air-fuel ratio, Spark timing, EGR on engine performance, Exhaust Catalytic converter, Oxidizing catalytic and Three- way type, Electronic fuel control, Open and Close Loop, EGO concentration, Intake manifold pressure, Speed density method, EGR, Electronic ignition.

Sensors and actuators:

Automotive variable, Air flow rate sensor, Pressure measurement, Strain gauge MAP sensor, Engine crankshaft angular position sensor, Magnetic reluctance position sensor, Engine angular speed sensor, Timing sensor for ignition and fuel delivery, Hall effect and optical position sensor, Optical crankshaft position sensor, Throttle angle sensor, temperature sensor, coolant sensor, Exhaust gas oxygen (EGO) sensor, Desirable and switching characteristics, Knock sensor, Angular rate sensor, LIDAR, Flex fuel sensor, Acceleration sensor, Fuel injection, Exhaust gas recirculation actuator, Variable valve timing, Electric motor actuator, Ignition system.

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 program, air bags.

Automotive standards and protocols:
Automotive standards like CAN protocol, LIN protocol, FLEX RAY, Head-Up Display (HUD), OBD-II, CAN FD, automotive Ethernet etc. Automotive standards like MISRA, functional safety standards (ISO 26262).

Text Books:

1. William B. Ribbens, Understanding Automotive Electronics, Butterworth-Heinemann publications, 7th Edition, 2012.

Reference Books:

1. Young A.P., Griffiths L., Automotive Electrical Equipment, ELBS and New Press, 2010.
2. Tom Weather Jr., Cland C. Hunter, Automotive computers and control system, Prentice Hall Inc., New Jersey,2009.
3. Crouse W.H., Automobile Electrical Equipment, McGraw Hill Co. Inc., New York, 2005.
4. Bechtold, Understanding Automotive Electronic, SAE, 2010.
5. BOSCH, Automotive Hand Book, Bentely Publishers, Germany, 9th Edition, 2014.

Course Outcomes:

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

1. Identify the automotive system and its components.
2. Attain knowledge of various sensors and conditioning circuit used in automotive systems.
3. Gain knowledge about various control strategies, the electronics and software used in automotive application.
4. Gain the basic ideas about the standards and protocols and energy management.

ICPE15 - INSTRUMENTATION AND CONTROL FOR POWER PLANT

Course type: Programme Elective (PE) ***Pre-requisites***: -
No. of Credits: 3

Course Objectives:

1. To expose the students to various power generation methods.
2. To impart knowledge on various processes/systems involved in thermal power generation.
3. To provide the knowledge on specific measurement techniques and control systems practiced in boiler and turbine units.
4. To impart basic knowledge in nuclear power plant and associated instrumentation.

Course Content:

Brief survey of methods of power generation-hydro, thermal, nuclear, solar and wind power – Introduction to thermal power plant processes – building blocks - ideal steam cycles – Boilers – types – sub-critical and super critical, Boiler - turbine units and its range systems, feed water systems, steam circuits, combustion process, products of combustion process, fuel systems, treatment of flue gases, steam turbine, condensate systems, alternator, feed water conditioning, turbine bypass valves. Importance of instrumentation in power generation – details of boiler processes, major P and I diagram for a boiler – combined cycle power plant, power generation and distribution.

Measurement in boiler and turbine: Metal temperature measurement in boilers, impulse-piping system for pressure measuring devices, flame monitoring. Introduction to turbine supervising system, pedestal vibration, shaft vibration, eccentricity measurement. Installation of non-contracting transducers for speed measurement, rotor and casing movement and expansion measurement.

Controls in boiler: Problems associated with control of multiple pulverizes. Draught plant: Introduction, natural draught, forced draught, induced draught, balanced draught, power requirements for draught systems. Fan drives and control, control of airflow. Combustion control: Fuel/Air ratio, oxygen, CO and CO2 trimming, combustion efficiency, excess air, parallel and cross limited combustion control, control of large systems.

Controls in boiler: Boiler drum level measurement methods, feedwater control, soot-blowing operation, steam temperature control, coordinated control, boiler following mode operation, turbine following mode operation, constant/ sliding pressure operation, selection between boiler and turbine following modes. Distributed control system in power plants-interlocks in boiler operation. Turbine control: Shell temperature control-steam pressure control – lubricant oil temperature control – cooling system.

Nuclear power plant instrumentation: Piping and instrumentation diagram of different types of nuclear power plant, Nuclear reactor control loops, reactor dynamics, excess reactivity, pulse channel and logarithmic instrumentation, control and safety instrumentation, reliability aspects.

Text Books:

1. Sam. G.Dukelow, The Control of Boilers, ISA Press, New York, 2nd Edition, 1991
2. Gill A.B, Power Plant Performance, Butterworth, London, 1984.
3. P.C Martin, I.W Hannah, Modern Power Station Practice, British Electricity International Vol. 1 andVI, Pergamon Press, London, 1992.
4. David Lindsley, Power-plant Control and Instrumentation: The Control of Boilers and HRSG Systems, IET, London, 2000.
5. Jervis M.J, Power Station Instrumentation, Butterworth Heinemann, Oxford, 1993.
6. Swapan Basu Ajay Debnath, Power Plant Instrumentation and Control Handbook, 1st Edition, Academic Press, 2014.
7. G. F. Gilman, Jerry Gilman, Boiler Control Systems Engineering, ISA, 2010.

Reference Books:

1. Elonka, S.M.and Kohal A.L, Standard Boiler Operations, McGraw-Hill, New Delhi, 1994.
2. Philip Kiameh, Power Plant Instrumentation and Controls, McGraw-Hill Professional, 2014.
3. Dipak.K. Sarkar, Thermal Power Plant, Design and Operation, Elsevier, ISBN: 978-0-12-801575-9,2015

Course Outcomes:

On the completion of this course, the students will be familiar with,

1. Various power generation processes.
2. Important parameters to be monitored and controlled in a thermal power plant.
3. Major control systems involved in the thermal power plant and nuclear power plants.

ICPE16 - INSTRUMENTATION AND CONTROL FOR PETROCHEMICAL INDUSTRIES

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To expose the students to various petroleum production processes.
2. To impart knowledge on various processes involved in petroleum refinery.
3. To provide knowledge on specific measurement techniques practiced, control systems and automationinvolved in petrochemical industry.

Course Content:

Brief survey of petroleum formation, petroleum exploration, Petroleum production, Petroleum refining and its methods, refining capacity and consumption in India, constituents of Crude Oil, Recovery techniques – Oil – Gas separation, Processing wet gases.

P and I diagram of petroleum refinery, Atmospheric distillation process, Vacuum distillation process, Thermal cracking, Catalytic cracking, Catalytic reforming, and Utility plants – Air, N_2, and cooling water.

Basics of field instruments, Parameters to be measured in Petrochemical industry, Distillation Column control, Selection of instruments, Basics of intrinsic safety of instruments, Area classification.

Control of furnace, Reboiler Control, Reflux Control, Control of catalytic crackers, Control of heat exchanger, Control of cooling tower.

Basics of PLC, and Safety interlocks in furnace, separator, pump, and compressor. Basics of SIL, Introduction to Standards.

Text Books:

1. Waddams A. L, Chemical from petroleum, Butter and Janner Ltd., 1968.
2. Balchan.J.G. and Mumme K.I., Process Control Structures and Applications, Van Nostrand ReinholdCompany, New York, 1988.

Reference Books:

1. Liptak B.G., Instrument Engineers' Handbook, CRC PRESS, 4th Edition, 2003.
2. Austin G.T. Shreeves, Chemical Process Industries, McGraw Hill International student edition, Singapore,1985.

Course Outcomes:

On completion of this course, the students will be familiar with,

1. Various petrochemical process and important parameters to be monitored and controlled.
2. Various instruments involved in and the control of petrochemical process.
3. The automation and safety standards of a petrochemical industry.

ICPE17 - INSTRUMENTATION AND CONTROL FOR PAPER INDUSTRIES

Course type: Programme Elective (PE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To familiarize the students to the paper making process.
2. To expose the students to the instrumentation used in Paper industries.
3. To expose the students to the control operations employed in paper industries.

Course Content:

Paper making process: Raw materials, pulping and preparation, screening – bleaching, cooking, chemical addition, approach system, paper machine, drying section, calenders, drive, finishing, other after treatment processes, coating.
Properties of paper: physical, electrical, optical and chemical properties.

Wet end Instrumentation: Conventional measurements at wet end, pressure and vacuum, temperature, liquid density and specific gravity, level, flow, consistency measurement, pH and ORP measurement, freeness measurement.

Dry end Instrumentation: Conventional measurements, moisture, basis weight, caliper, coat thickness, optical variables, measurement of length and speed.
Digester: Rotary and Batch type.

Control aspects: Machine and cross direction control techniques, control of pressure, vacuum, temperature, liquid density and specific gravity, level, flow, pH, freeness, thickness, consistency, basis weight and moisture.

Pumps and control valves used in paper industry, flow box and wet end variables, evaporator feedback and feed forward control, lime mud density control, stock proportioning system, refiner control instrumentation, basic pulper instrumentation, headbox – rush/drag control. Instrumentation for size preparation, coating preparation, coating weight control. Batch digester, K/Kappa number control, Bleach plant chlorine stage control.

Text Books

1. E. J. Cole, William Harold Mehaffey. Pulp and Paper Mill Instrumentation, Lockwood Trade Journal Company. (1957)
2. John R. Lavigne, An introduction to paper industry Instrumentation, Miller Freeman Publications, California,1977.
3. Robert J. McGill, Measurement and Control in Papermaking, Adam Hilger Limited, Bristol, 1980.
4. John R. Lavigne, Instrumentation Applications for the Pulp and Paper Industry, Backbeat Books, California,1979.
5. Dr. Nancy J. Sell , Process Control Fundamentals for the Pulp and Paper Industry , TAPPI Press,1995.

Reference Books

1. James P. Casey, Pulp and Paper: Chemistry and Chemical Technology, John Wiley Sons, NewYork, 3rd Edition, 1983.
2. Sankaranayanan P.E, Pulp and Paper Industries–Technology and Instrumentation, Kothari'sDeskbook series,1995.
3. Liptak B.G, Instrument Engineers Handbook, volume 2: Process Control, CRC press, London, 4th Edition,2005.
4. H. N. Koivo, Automation and Control of Pulp and Paper Process, Helsinki University of Technology Publication, Espoo. (2002)

Course Outcomes:

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

1. Appreciate the need of instrumentation and control in paper making.
2. Understand the instrumentation and control used in paper and pulp industry.
3. Suggest and analyse new instruments and control options in paper and pulp industry.

ICPE18 - INSTRUMENTATION FOR AGRICULTURAL AND FOODPROCESSING INDUSTRIES

Course type: Programme Elective (PE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To provide an understanding on the need of instrumentation in agriculture and food processing sector.
2. To provide an understanding of food quality assessment and instruments used for the same.
3. To provide an understanding on agriculture associated activities and instruments used for the same.
4. To provide some knowledge in food processing equipment.

Course Content:

Introduction: Necessity of instrumentation and control for food processing and agriculture sensor requirement, remote sensing, biosensors in Agriculture, standards for food quality.

Instrumentation for food quality assurance: Instrumental measurements and sensory parameters. Inline measurement for the control of food processing operations: color measurements of food, food composition analysis using infrared, microwave measurements of product variables, pressure and temperature measurement in food process control, level and flow measurement in food process control, ultrasonic instrumentation in food industry. Instrumental techniques in the quality control, Major Processes: Flow diagram of sugar plant, sensors and instrumentation set-up for it, Oil extraction plant and instrumentation set-up, Juice extraction control set-up.

Instrumentation for Agriculture: Irrigation systems: necessity, irrigation methods: overhead, centre pivot, lateral move, micro irrigation systems and it's performance, comparison of different irrigation systems, soil moisture measurement methods. Major Processes: Application of SCADA for DAM parameters and control, Water distribution and management control, Auto-Drip irrigation systems, Irrigation Canal management, upstream and downstream control concepts, supervisory control.

Green houses and Instrumentation: Ventilation, cooling and heating wind speed, temperature and humidity, rain gauge, carbon dioxide enrichment measurement and control.

Design considerations of agricultural and food Processing Equipments: Design of Food Processing equipments, dryers, design of dryers PHTC, RPEC, LSU and Drum Dryer, determination of heat and air requirement for drying grains.

Text Books:

1. Erika Kress-Rogers, Christopher J.B. Brimelow., Instrumentation and Sensors for the Food Industry, Woodhead Publishing, 2001 .
2. Manabendra Bhuyan., Measurement and control in food processing, CRC/Taylor and Francis Publications, 2007

3. P.J. Fellows, Food Processing Technology Principles and Practice, Woodhead Publishing, 3rd Edition, 2009.
4. Semioh Otles, Methods of analysis of food components and additives, CRC Press, Taylor and Francis group, 2nd Edition, 2012.

Reference Books:

1. McMillan G. K., Considine D. M., Process/Industrial Instruments and Controls Handbook, McGraw Hill International, 5th edition,1999.
2. Liptak B. G., Instrument Engineers Handbook, Process Measurement Volume I and Process Control Volume II, CRC press, 4th Edition,2005.
3. Hall C. W., Olsen W. C, The literature of Agriculture Engineering, Cornell University Press, 1992.
4. Sahu J. K., Fundamentals of Food Process Engineering, Alpha Science Intl Ltd, 2016.
5. G.E. Meyer and Yufeng Ge., Instrumentation and Controls for Agricultural and Biological Engineering Applications, using LabVIEW® and other Modern tools as Support Systems, (2008)

Course Outcomes:

On completion of this course, the students will be,

1. Able to understand the necessity of instrumentation in agriculture and food processing.
2. Familiarized with instrumentation requirement in agriculture and food processing.
3. Able to analyse and design systems/instruments for agriculture and food processing.
4. Able to understand problems in agriculture and food processing and provide technological solution to the same.

ICPE19 – PIPING AND INSTRUMENTATION DIAGRAMS

Course type: Programme Elective (PE)
No. of Credits: 3
***Pre-requisites*:** ICPC20

Course Objectives:

1. To introduce various flow sheet design using process flow diagram.
2. To impart knowledge on PandI D symbols for pumps, compressors and process vessels.
3. To teach the line diagram symbols, logic gates of instruments.
4. To learn the simulation software for PandID implementations

Course Content:

Flow sheet design: Types of flow sheets, flow sheet presentation, flow sheet symbols, line symbols and designation,process flow diagram, synthesis of steady state flowsheet, flow sheeting software.

Piping and instrumentation diagram evaluation and preparation: P and I D Symbols, line numbering, line schedule,PandI D development, various stages of PandI D, PandI D for pumps, compressors process vessels, absorber, evaporator.

Control systems and interlocks for process operation: Introduction and description, need of interlock, types ofinterlocks, interlock for pumps, compressor, heater-control system for heater, distillation column, expander

Instrument line diagram: Line diagram symbols, logic gates, representation of line diagram.

Application of Pand ID'S: Applications of Pand ID in design state, construction stage, commissioning state, operatingstage, revamping state, applications of PandID in HAZAMPS and risk analysis

Text Books

1. Ernest E. Ludwig, Applied Process Design for Chemical and Petrochemical Plants Vol-1, GulfPublishing Company, Hoston,1989.
2. Max. S. Peters and K.D. Timmerhaus, Plant Design and Economics for Chemical Engineers,McGraw Hill Inc., New York,1991.
3. Moe Toghraei., Piping and Instrumentation Diagram Developmen ., Wiley-AIChe Publication. 2019.

Reference Books

1. Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGraw Hill, NewDelhi,1981.
2. A.N. Westerberg et al., Process Flow sheeting, Cambridge University Press, NewDelhi,1979.
3. Jagadeesh Pandiyan.,Introduction to Smart Plant (R) PandID: The Piping and Instrumentation Diagrams (PandID)Handbook ,. APJ Books Publisher 2020 Edition,

Course Outcomes:

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

1. Understand of PandI diagrams standards involved and its preparation.
2. Select different fittings for instruments installation used for the preparation of PandIDs.
3. Apply software for preparation of PandIDs.
4. Apply the P and ID concepts for industrial applications

ICPE20 - ASSISTIVE DEVICES

Course Type: Programme Elective (PE) Pre-requisites**: -**

No. of Credits: 3

Course Objectives

1. To understand the concepts of various rehabilitation equipments for human movements and applications
2. To understand and gain knowledge about different hearing aids
3. To study various assist devices for visually and auditory impaired
4. To study the various orthotic devices and prosthetic devices to overcome orthopedic problems
5. Understand the various mobility aids
6. Learn about manual and powered wheelchairs for the evaluation of human-technology interfaces
7. Understand key terminology used by various aids within the disability community and its roles.

Course Content

Introduction to the Human body system, Principles of Assistive and Rehabilitation Technology, Design considerations, standards and key approaches to rehabilitation and Assistive Technology.

Assistive Devices for Persons with Engineering Heart and Circulatory problem - Anatomy of Heart and circulatory system, Heart Assist Technology- Blood Pumps and Prosthetic Heart Valves.

Assistive Devices for Persons with Visual Impairments - Anatomy of eye, Categories of visual impairment – Cortical and retinal implants, Blind mobility aids –reading writing - graphics access and Braille Reader, Tactile devices for visually challenged, Text to voice converter, Orientation and navigation Aids –Ultra sonic canes and laser canes.

Assistive Devices for Persons with Hearing Impairments - Anatomy of ear -hearing functional assessment, Types of deafness, Hearing aids- Cochlear implants, Assistive technology for hearing Tactile -Information Display- Voice synthesizer and speech trainer.

Anatomy of upper and lower extremities, Classification of amputation types, Prosthesis prescription - Components of upper and lower limb prosthesis, Different types of models for limb prosthetics- Body powered prosthetics- Myoelectric controlled prosthetics and Externally powered limb prosthetics. Functional Electrical Stimulation Systems-Restoration of hand function, restoration of standing and walking, Hybrid Assistive Systems (HAS).

Concepts of Manipulation and mobility Aids, Grabbers, feeders, and page turners, Classification of manual and special purpose wheelchairs -Manual wheelchairs – Electric power wheel chairs - Power assisted wheel chairs -Wheel chair standards and tests, sports and racing wheel chairs.

Text Books

1. Albert M. Cook and Janice M. Polgar, Assistive Technologies Principles and Practice, 4th Edition, Elsevier, 2015.
2. Cooper Rory A, An Introduction to Rehabilitation, Taylor and Francis, London, 2012
3. Joseph D. Bronzino, Handbook of Biomedical Engineering, 2nd Edition –Volume II, CRC press, 2010
4. Muzumdar A, Powered Upper Limb Prostheses – Control, Implementation and Clinical Application, Springer, 2004.
5. Cook A.M. and Hussey S.M., Assistive Technologies: Principles and Practice, Mosby, USA, 1995.

Reference Books

1. Teodorescu H.L.and Jain L.C., Intelligent systems and technologies in rehabilitation engineering, CRC Press, 2001.
2. Warren E. Finn, Peter G. LoPresti, Handbook of Neuroprosthetic Methods, CRC; edition 2002.
3. Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, "An Introduction to Rehabilitation Engineering", CRC Press, 2006.
4. Marion A Hersh, Michael A, Johnson, Assistive Technology for Visually impaired and blind people", Springer Publications, 1st Edition, 2008.
5. Albert M. Cook, Janice Miller Polgar, Essentials of Assistive Technologies, Elsevier 2012.
6. Roberto Manduchi, Sri Kurniawan , Assistive Technology for Blindness and Low Vision, 1st Edition, CRC Press, 2017.

Course Outcomes

1. Gain adequate fundamental knowledge about the needs of rehabilitations and its future development.
2. Design and apply different types of Hearing aids, visual aids and their application in biomedical field and hence the benefit of the society.
3. Gain in-depth knowledge about various assistive technologies for vision and hearing
4. Develop and Compare the different methods of orthopedic prosthetics for rehabilitation.
5. Select the appropriate rehabilitation concept for various disabilities.
6. Apply basic design and analytical skills to model various types of Wheel Chairs for varied needs.

ICPE21 - MEDICAL DIAGNOSTIC AND THERAPEUTIC INSTRUMENTATION

Course type: Programme Elective (PE) **Pre-requisites:** -
No. of Credits: 3

This course will cover the various medical diagnostics and Therapeutic Equipment's used in health care.

Course objectives:

1. To familiarise on patient monitoring systems and telemedicine
2. To understand medical imaging systems
3. To explain extracorporeal devices used in critical care
4. To educate the importance of patient safety against electrical hazard

Course contents:

Patient monitoring systems, Intensive cardiac care, bedside and central monitoring systems - Infusion pumps, Central consoling controls. Patient monitoring through telemedicine.

X ray machine, Computer tomography, ultrasonic imaging system, magnetic resonance imaging system, thermal imaging system, positron emission tomography.

Cardiac Pacemaker, Defibrillator, Pneumotachometer, Thoracic pressure measurements, Heart lung machine - functioning of bubble, disc type and membrane type oxygenators, finger pump, roller pump, electronic monitoring of functional parameters. Types of Ventilators, Humidifiers, Nebulizers, Inhalators, Hemo Dialyser unit, Incubators.

IR, UV lamp and LASER application, Short wave diathermy, ultrasonic diathermy, Microwave diathermy, Electro surgery machine - Current waveforms, Tissue Responses, Lithotripsy, Principles of Cryogenic technique and application, Endoscopy, Laparoscopy, Otoscopes, Audiometer, Tonometer

Sources of electrical hazards and safety techniques, Built-in safety features for medical instruments, physiological effects of electricity, Patient 's electrical environment, Electrical safety codes and standards.

Text Books

1. James E. Moore Jr., Biomedical Technology and Devices , 2nd Edition ,2014, CRC Press.
2. John G. Webster, Medical Instrumentation Application and Design‖ , 5th edition, Wiley India Pvt Ltd, New Delhi,2020.
3. Robert B. Northrop, Non-Invasive Instrumentation and Measurement in Medical Diagnosis , 2nd edition, CRC Press,. 2019.
4. Joseph J.Carrand ,John M. Brown, ―Introduction to Biomedical Equipment Technology, Pearson education,2012.
5. Raghbir Singh Khandpur., Compendium of Biomedical Instrumentation, 3 Volume Set, Wiley India Pvt. Ltd, 2019.

References:

1. Leslie Cromwell, Biomedical Instrumentation and Measurement‖, 2nd Edition, Prentice hall of India, New Delhi, 2015.
2. L.A. Geddes and L.E. Baker, Principles of Applied Biomedical Instrumentation, John Wiley, New York, 3rd Edition, 2009.
3. Khandpur R.S, Handbook of Biomedical Instrumentation‖, 3rd Edition, Tata McGraw-Hill, New Delhi, 2014.

Course outcomes:

At the end of the course, the student should be able to:

1. Familiar with patient monitoring equipment used in hospitals and in telemedicine.
2. Familiar with various imaging techniques used for diagnosis.
3. Discuss extracorporeal devices used in hospital
4. Explain the types of diathermy and its applications.
5. Understand the importance of patient safety against electrical hazard

ICPE22 - PRODUCT DESIGN AND DEVELOPMENT (THEORY and PRACTICE)

Course type: Programme Elective (PE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives

1. The aim of this course is to inculcate into the student the spirit of innovation and entrepreneurship. This is achieved in this course by making the students to develop a marketable product on their own as a group. At the end of this semester course, the students will learn how to know the needs of the society and solve them using the technical knowledge at their disposal.
2. The students will learn some of the general concepts needed for new product development and simultaneously learn how to interact with the society outside the campus to learn about its needs. They also learn about how to get prototypes fabricated outside the campus.
3. The students will fabricate an alpha prototype and test it for its conformity to the design specifications at the beginning of the next academic session
4. After demonstration of the alpha prototype, they proceed to fabricate a beta prototype that is acceptable in the market-place

Course Content

TOPICS COVERED BY LECTURES

Introduction to product design – Product planning – Identifying customer needs – Project selection – Concept generation – Concept testing – Concept selection. Product specification – Product architecture
– Industrial design – Robust design. Product development economics – Design for manufacturing – Supply chain design – Intellectual property – Design for environment.

PRACTICAL WORK

Interaction with public outside the campus- identifying customer needs- product selection based on customer needs- concept generation- concept testing.

Identifying fabrication requirements- Identifying fabricators for the project- costing- financial model for the product development- finding outside finance for product development if possible and required - patent search for the product.

1. Alpha prototype fabrication and testing-to be submitted at the end of the semester with customer acceptance survey

Course Evaluation

Theoretical and Practical part will be evaluated separately and grades will be awarded. Theoretical component will be evaluated during the semester (50%) and the practical component (50%) will be evaluated at the end of the semester.

ICPE23 - DIGITAL CONTROL SYSTEMS

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To introduce the digital implementation of control systems
2. To review the classical techniques and highlight the practical difficulties
3. To emphasize on the time-domain and state-space implementation using digital processors, and exposethe students to industrial practice using PLCs.
4. To design discrete-time controllers for hybrid systems

Course Content:

Introduction to digital control systems, Review of discrete-time signals and systems, difference equations, transferfunctions, Z-transforms

Digital Controller Design using root locus and Bode plot, digital PID controllers design using time domain andfrequency domain techniques.

Review of Modern Control systems, Modelling multi-variable difference equations as state-space canonical models,Solution of discrete-time state equation. Computational methods.

Stability analysis of discrete-time systems, Jury 's criterion, Lyapunov theory

Design using state-space methods: controllability and observability, control law design, pole placement, Full orderand reduced order discrete observer design – Introduction to Kalman filter

Implementation of digital control systems using DSPs and Microcontrollers, Large-scale industrial applications usingPLCs and SCADA, Introduction to Discrete-event systems and Hybrid Systems

Text books:

1. M. Gopal, Digital Control and state variable methods, Tata McGraw Hill, 4th edition., 2014.
2. M.S. Santina, A.R. Stubberud, and G.H. Hostetter, Digital Control System Design, 2nd Edition, Oxford Univ. Press,

Reference books:

1. B. C. Kuo, Digital Control System, Oxford University Press, 2nd Edition., 2007.
2. G. F. Franklin, J. D. Powell and M. L. Workman, Digital Control of Dynamic Systems, Pearson Education,3rd Edition, 2000.

Course outcomes:

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

1. Analyze the performance and stability of a discrete-time control system.
2. Design state-space digital controllers and implement using processors and PLCs.
3. Learn about event driven and hybrid systems.
4. Understand implementation issues for computer-based control systems

ICPE24 - BUILDING AUTOMATION

Course type: Programme Elective (PE) ***Pre-requisites***: -
No. of Credits: 3

Course Objectives:

1. To introduce the basic blocks of Building Management System.
2. To impart knowledge in the design of various sub systems (or modular system) of building automation.
3. To provide insight into some of the advanced principles for safety in automation.
4. To Design energy management system.

Course Content:

Introduction:
Concept and application of Building Management System (BMS) and Automation, requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS.

HVAC system:
Different components of HVAC system like heating, cooling system, chillers, AHUs, compressors and filter units and their types. Design issues in consideration with respect to efficiency and economics, concept of district cooling and heating.

Access control and security systems:
Concept of automation in access control system for safety, Physical security system with components, Access control components, Computer system access control – DAC, MAC, and RBAC.

Fire and alarm system:
Different fire sensors, smoke detectors and their types, CO and CO_2 sensors, Fire control panels, design considerations for the FA system, concept of IP enabled fire and alarm system, design aspects and components of PA system.

CCTV system and energy management system:
Components of CCTV system like cameras, types of lenses, typical types of cables, controlling system, concept of energy management system, occupancy sensors, fans and lighting controller. Introduction to structural health monitoring and methods employed.

Text Books:

1. Jim Sinopoli, Smart Buildings, Butterworth-Heinemann imprint of Elsevier,2nd Edition., 2010.
2. Albert Ting Pat So, WaiLok Chan, Intelligent Building Systems, Kluwer Academic publisher, 3rd Edition., 2012.
3. Reinhold A. Carlson, Robert A. Di Giandomenico, Understanding Building Automation Systems, published by R.S. Means Company, 1991.
4. Morawski, E, Fire Alarm Guide for Property Managers, Publisher: Kessinger Publishing, 2007.

Reference Books:

1. Building Automation: Control Devices and Applications by In Partnership with NJATC (2008).
2. Building Control Systems, Applications Guide (CIBSE Guide) by The CIBSE (2000).
3. Phil Zito., Building Automation Systems a to Z: How to Survive in a World Full of Bas, CreateSpace Independent Pub, 2016.
4. James Backer (Translator), Viktoriya Moser (Translator), Leena Greefe (Translator).,Building Automation: Communication systems with EIB/KNX, LON and BACnet (Signals and Communication Technology), Springer publication. (2018)

Course Outcomes:

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

1. Understand the concept behind building automation.
2. Plan for building automation.
3. Design sub systems for building automation and integrate those systems.
4. Learn to design energy efficient system.

ICPE25 – NON-LINEAR CONTROL

Course type: Programme Elective (PE) ***Pre-requisites:*** ICPC19
No. of Credits: 3

Course Objectives:

1. To introduce and elaborate the characteristics of nonlinear systems.
2. To gain understanding in the methods (both classical and modern) of analysis of stability and performance ofnonlinear systems
3. To study the design of controllers as applicable to various case studies in robotics, aerospace and otherdomains.
4. To introduce the notion of complex systems theory and large-scale real-world problems

Course Content:

Introduction – Modeling one-dimensional and two-dimensional dynamics, Existence and uniqueness of solutions

Approximate analysis methods: The phase plane, Index theory, Poincare-Bendixson theorem, Describing functionanalysis

Lyapunov theory for autonomous and non-autonomous systems, Attractors and Basins, Poincare maps

Nonlinear control system design: Sliding control, Basics of Differential geometry, feedback linearization, single-input and multi-input cases

Introduction to Chaos, Bifurcations, Hamiltonian Systems. Cases of Mechanisms, Robotics

Text Books:

1. Jitendra R Raol, Ramakalyan Ayyagari, Control Systems: Classical, Modern, and AI-Based Approaches,CRC Press (Taylor and Francis), 2019
2. Jean-Jacques E. Slotine, Applied Nonlinear Control, Prentice Hall Englewood Cliffs, New Jersey, 1991.
3. Khalil, H.K., Nonlinear Systems, Prentice Hall Englewood Cliffs, New Jersey, 3rd Edition, 2002.
4. Meiss, J.D., Differential Dynamical Systems, SIAM, 2007

Reference Books:

1. Strogatz, S. H., Nonlinear Dynamics and Chaos, with Applications to Physics, Biology, Chemistry andEngineering, 2nd Edition, Westview Press, 2014.
2. Vidyasagar.M, Nonlinear System Analysis, 2nd Edition, SIAM, 2002.
3. Sontag, Mathematical Control Theory, 2nd Edition, Springer Verlag, 1998

Course Outcomes:

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

1. Differentiate between linear and nonlinear systems and their behaviour.
2. Apply various graphical and analytical tools to describe and analyse nonlinear systems
3. Understand Lyapunov theory.
4. Learn a range of controller design techniques suitable for nonlinear control systems

ICPE26 – SYSTEM IDENTIFICATION

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To introduce empirical and data-based modeling of large-scale systems.
2. To train the students in parametric and nonparametric statistical models and estimation techniques.
3. To expose to the students, the algorithms and computational overheads involved in large-scale systemmodeling and control.

Course Content:

Introduction, Development of parameter estimators, Least-Squares estimation – linear least-squares, generalized least-squares, nonlinear least-squares, Sufficient statistics, Analysis of estimation errors, MMSE, MAP and ML estimators, sequential least-squares, asymptotic properties, General convergence results.

Introduction to system identification: identification based on differential equations, Laplace transforms, frequency responses, difference equations. Stationarity, auto-correlation, cross-correlation, power spectra. Random and deterministic signals for system identification: pulse, step, pseudo random binary sequence (PRBS), signal spectral properties, persistent excitation.

Estimates of the plant impulse, step and frequency responses from identification data, Correlation and spectral analysis for non-parametric model identification, parametric Models-Equation error, output error models, and determination of model order.

Parametric estimation using one-step ahead prediction error model structures and estimation techniques for ARX, ARMAX, Box-Jenkins, FIR, Output Error models. Residual analysis for determining adequacy of the estimated models. Recursive system identification.

Kalman filtering and other nonlinear filters

Reference Books:

1. Arun K. TanIRala, Principles of System Identification: Theory and Practice, First Edition, CRC Press, 2014
2. Karel J. Keesman, System Identification: An Introduction, Springer-Verlag London, 2011
3. L.Ljung, System Identification: Theory for the User, 2nd Edition, Prentice-Hall, 1999
4. Y. Zhu, Multivariable System Identification for Process Control, Pergamon, 2001
5. T. Söderström and P. Stoica, System Identification, Prentice Hall International, Hemel Hempstead, PaperbackEdition, 1994
6. O. Nelles, Nonlinear System Identification, Springer-Verlag, Berlin, 2001

Course Outcomes

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

1. Conduct experiments, design suitable inputs and generate data for system identification.
2. Identify the model structure and order determination for an unknown process from empirical data.
3. Apply estimation techniques for parametric and nonparametric models.
4. Identify and validate the model for practical process applications

ICPE27 - FAULT DETECTION AND DIAGNOSIS

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC16
No. of Credits: 3

Course Objectives:

1. To impart knowledge in fault detection and identification.
2. To introduce different structure residual technique for the fault identification.
3. To introduce different directional residual technique for the fault identification.
4. To impart the knowledge in soft computation technique based FDI design

Course Content:

Introduction to Fault Detection and Diagnosis: 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: Introduction- Mathematical representation of Fault 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: Introduction- Residual structure of single fault Isolation: Structural and Canonical structures- Residual structure of multiple fault Isolation: Diagonal and Full Row canonical concepts – Introduction to parity equation implementation and alternative representation.

Design of Directional Residuals: Introduction – Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation – Linearly dependent column.

Advanced level issues and design involved in FDD: Introduction of Residual generation of parametric fault – Robustness Issues –Statistical Testing of Residual generators – Application of Neural and Fuzzy logic schemes in FDD – Case study.

Text Books:

1. Janos J. Gertler, Fault Detection and Diagnosis in Engineering systems, Macel Dekker, 2nd Edition, 1998.
2. Rolf Isermann, Fault-Diagnosis Systems: An Introduction from Fault Detection to Fault Tolerance, Springer Verlag, 2011.

Reference Books:

1. Sachin. C. Patwardhan, Fault Detection and Diagnosis in Industrial Process – Lecture Notes, IIT Bombay, February 2005.
2. Rami S. Mangoubi, Robust Estimation and Failure detection. Springer-Verlag-London 1998.
3. Steven X. Ding, Model based Fault Diagnosis Techniques: Schemes, Algorithms, and Tools, Springer Publication, 2012.

4. Hassan Noura, Didier Theilliol, Jean-Christophe Ponsart, Abbas Chamseddine, Fault Tolerant Control Systems: Design and Practical Applications, Springer Publication, 2009.
5. Mogens Blanke, Michel Kinnaert, Jan Lunze, Marcel Staroswiecki., Diagnosis and Fault-Tolerant Control, Springer, 2016.

Course Outcomes:

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

1. Identify the different type of faults occurred in a system.
2. Apply mathematical techniques to detect faults.
3. Apply structured and directional techniques for FDI design.
4. Apply soft computation technique for FDI development.

ICPE28 - COMPUTATIONAL TECHNIQUES IN CONTROL ENGINEERING

Course type: Programme Elective (PE) ***Pre-requisites*:** **ICPC19**
No. of Credits: 3

Course Objectives:

1. To impart knowledge with an emphasis on control system design in the current computer era.
2. To teach the interdisciplinary necessity of linear algebra, control theory, and computer science.
3. To demonstrate that control problems in practice demand efficient algorithms
4. To discuss about algorithms useful for practicing engineers for easy implementation on a range of computers.

Course Content:

Review of Linear Algebra – Vector spaces, Orthogonality, Matrices, Vector and Matrix Norms, Kronecker Product.

Numerical Linear Algebra – Floating point numbers and errors in computations, Conditioning, Efficiency, Stability, and Accuracy, LU Factorization, Numerical solution of the Linear system Ax = b, QR factorization, Orthogonal projections, Least Squares problem, Singular Value Decomposition, Canonical forms obtained via orthogonal transformations.

Control Systems Analysis – Linear State-space models and solutions of the state equations, Controllability, Observability, Stability, Inertia, and Robust Stability, Numerical solutions and conditioning of Lyapunov and Sylvester equations.

Control Systems Design – Feedback stabilization, Eigen value assignment, Optimal Control, Quadratic optimization problems, Algebraic Riccati equations, Numerical methods and conditioning, State estimation and Kalman filter.

Large scale Matrix computations, Some Selected Software – MATLAB, MATHEMATICA, SCILAB.

Text Books:

1. B.N. Datta, Numerical Methods for Linear Control Systems, Academic Press/Elsevier, 2005
2. G.H. Golub and C.F. Van Loan, Matrix Computations, 4^{th} Edition, John Hopkins University Press,2007
3. A. Quarteroni, F. Saleri, Scientific Computing with MATLAB, Springer Verlag, 2003.

Reference Books:

1. www.scilab.org
2. G. Strang, Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019
3. N. Higham, Accuracy and Stability of Numerical Algorithms, 2^{nd} Edition, SIAM, 2002

Course Outcomes:

On completion of this course, the students will,

1. Acquire skills and numerical solutions of state equations and frequency response computations.
2. Be able to develop numerical algorithms for evaluation of controllability, observability, and stability.
3. Acquire skills in numerical solutions for conditioning of Lyapunov and algebraic Riccati equation
4. Be able to obtain large-scale solutions of control problems.

ICPE29 - PROCESS MODELLING AND OPTIMIZATION

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To impart knowledge with an emphasis on control system design in the current computer era.
2. To teach the interdisciplinary necessity of linear algebra, control theory, and computer science.
3. To demonstrate that control problems in practice demand efficient algorithms
4. To discuss about algorithms useful for practicing engineers for easy implementation on a range of computers.

Course Content:

Review of Linear Algebra – Vector spaces, Orthogonality, Matrices, Vector and Matrix Norms, Kronecker Product.

Numerical Linear Algebra – Floating point numbers and errors in computations, Conditioning, Efficiency, Stability, and Accuracy, LU Factorization, Numerical solution of the Linear system Ax = b, QR factorization, Orthogonal projections, Least Squares problem, Singular Value Decomposition, Canonical forms obtained via orthogonal transformations.

Control Systems Analysis – Linear State-space models and solutions of the state equations, Controllability, Observability, Stability, Inertia, and Robust Stability, Numerical solutions and conditioning of Lyapunov and Sylvester equations.

Control Systems Design – Feedback stabilization, Eigen value assignment, Optimal Control, Quadratic optimization problems, Algebraic Riccati equations, Numerical methods and conditioning, State estimation and Kalman filter.
Large scale Matrix computations, Some Selected Software – MATLAB, MATHEMATICA, SCILAB.

Text Books:

1. B.N. Datta, Numerical Methods for Linear Control Systems, Academic Press/Elsevier, 2005 (Low costIndian edition available including CD ROM).
2. G.H. Golub and C.F. Van Loan, Matrix Computations, 4th Edition, John Hopkins University Press, 2007 (Lowcost Indian edition available from Hindustan Book Agency).
3. A. Quarteroni, F. Saleri, Scientific Computing with MATLAB, Springer Verlag, 2003.

Reference Books:

1. www.scilab.org
2. G. Strang, Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019
3. Jitendra R. Raol, Ramakalyan Ayyagari, Control Systems – Classical, Modern and AI-Based Approaches,CRC Press Taylor and Francis Group

Course Outcomes:

On completion of this course, the students will,

1. Acquire skills and numerical solutions of state equations and frequency response computations.
2. Be able to develop numerical algorithms for evaluation of controllability, observability, and stability.
3. Acquire skills in numerical solutions for conditioning of Lyapunov and algebraic Riccati equation
4. Be able to obtain large-scale solutions of control problems.

ICPE30 – CONTROL SYSTEM COMPONENTS

Course type: Programme Elective (PE) ***Pre-requisites*: -**
No. of Credits: 3

Course Objectives:

1. To expose the students to various electrical components used in industrial control systems.
2. To expose the students to various mechanical components used in industrial control systems
3. To teach various mechanical and pneumatic systems used in industrial control systems.
4. To introduce the concept of hydraulic pumps, actuators and valves.

Course Content:

Motors:
Types, working principle, characteristic, and mathematical model of following: Motors AC/DC motors, Brushless DC motor, stepper, servo, linear, Synchronous, Generators, and Alternator

Types, working principle, characteristics, and symbolic representation of following: Switches: Toggle, Slide, DIP, Rotary, Thumbwheel, Selector, Limit, Proximity, Combinational switches, zero speed, belt sway, pull cord. Relays: Electromechanical, Solid state relays, relay packages. Contactors: Comparison between relay and contactor, contactor size and ratings. Timers: On Delay, off delay and Retentive.

Sequencing and Interlocking for motors: Concept of sequencing and Interlocking, Standard symbols used for Electrical Wiring Diagram, Electrical Wiring diagrams for Starting, Stopping, Emergency shutdown, (Direct on line, star delta, soft starter) Protection devices for motors: Short circuit protection, Over load Protection, Over/ under voltage protection, Phase reversal Protection, high temperature and high current Protection, over speed, Reversing direction of rotation, Braking, Starting with variable speeds, Jogging/Inching Motor Control Center: Concept and wiring diagrams

Pneumatic components: Pneumatic Power Supply and its components: Pneumatic relay (Bleed and Non-bleed, Reverse and direct), Single acting and Double acting cylinder, Special cylinders: Cushion, Double rod, Tandem, Multiple position, Rotary Filter Regulator Lubricator (FRL), Pneumatic valves (direction-controlled valves, flow control etc.), Special types of valves like relief valve, pressure reducing etc. Hydraulic components: Hydraulic supply, Hydraulic pumps, Actuators (cylinder and motor), Hydraulic valves

Text Books:

1. M. D. Desai, Control System Components, PHI, 2008.
2. J. E. Gibson and F. B. Tuteur, Control system components, McGraw Hill, 2013
3. S. R. Majumdhar, Pneumatic Systems, Tata McGraw-Hill Publisher, 2009.

Reference Books:

1. Meixner H and Sauer E, Intro to Electro-Pneumatics, Festo didactic, 1st Edition, 1989.
2. Hasebrink J P and Kobler R, Fundamentals of Pneumatic Control Engineering, FestoDidactic: Esslinger (W Germany), 1989.
3. Petruzella, Industrial Electronics, McGraw-Hill International 1st Edition, 1996.

Course Outcomes:

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

1. Select and use of different process control components for electrical systems.
2. Select and use of different process control components for mechanical system.
3. Identify, formulate and solve a problem using pneumatic system in instrumentation and control engineering.
4. Identify, formulate and solve a problem using hydraulic system in instrumentation and control engineering.

ICPE31 – NETWORK CONTROL SYSTEMS

Course type: Programme Elective (OE) ***Pre-requisites*:** -
No. of Credits: 4

Course Objectives

1. To expose the students to the emerging field of multi-agent and network control systems
2. To expand the scope of traditional control systems to include large-scale interconnected systems
3. To demonstrate consensus and leader-follower paradigms in a distributed environment
4. To introduce different applications that fall in the gamut of network control systems.

Course Content

Introduction to multi-agent systems, Information exchange via local interactions, Basics of graph theory

Reaching agreement in undirected and directed networks, Agreement via Lyapunov functions, Agreement over random networks

Formation control, Shape based control, Dynamic formation selection, Assigning roles, Cooperative robotics, Wireless sensor networks

Graph theoretic controllability, Network formation, Optimizing the weighted agreement, Planning over proximity graphs, Higher order networks

Introduction to social networks, opinion dynamics, epidemics, games etc.

Text Books

1. Mehran Mesbahi and Magnus Egerstedt, Graph Theoretic Methods in Multiagent Networks, Princeton University Press, 2010.
2. F. Bullo, J. Cortes, and S. Martinez, Princeton, Distributed Control of Robotic Networks, University Press, 2009.

Reference Books

1. P. J. Antsaklis and P. Tabuada, Networked Embedded Sensing and Control, Springer, 2006.
2. A.L. Barabasi, Network Science, Cambridge University Press,2016

Course Outcomes

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

1. Design control system in the presence of quantization, network delay or packet loss.
2. Understand distributed estimation and control suited for network control system.
3. Develop simple application suited for network control systems.
4. Technically understand larger-scale techno-socio-economic networks and models prevalent in today’s society.

ICPE32 – ROBOTICS

Course type: Programme Elective (PE) ***Pre-requisites***: -
No. of Credits: 3

Course Objectives:

1. To trace the development of machines that have been aiding humans to simplify mundane jobs
2. To introduce the importance of automation in the modern world.
3. To introduce robotics in the fields of manufacturing, medicine, search and rescue, service, and entertainment.
4. To teach robotics as the synergistic integration of mechanics, electronics, controls, and computer science.

Course Content:

Introduction: Basic concepts, definition and origin of robotics, different types of robots, robot classification, applications, robot specifications.

Introduction to automation: Components and subsystems, basic building block of automation, manipulator arms, wrists and end-effectors, user interface, machine vision, implications for robot design, controllers. Kinematics, dynamics and control:

Robot programming: Robot programming languages and systems, levels of programming robots, problems peculiar to robot programming, control of industrial robots using PLCs.

Automation and robots: Case studies, multiple robots, machine interface, robots in manufacturing and non-manufacturing applications, robot cell design, selection of a robot.

Robotic network models, complexity notion, connectivity, maintenance, and rendezvous

Text Books

1. Corke, P., Robotics, Vision and Control, 2nd edition, Springer,2017
2. Spong, M.W., Hutchinson, H., and Vidyasagar, M., Robot Modeling and Control, JohnWiley (Wiley India Ed.),2006.
3. Asfahl C.R, Robots and Manufacturing Automation, John Wiley and Sons, New York,1992.
4. F. Bullo, J. Cortes, and S. Martinez, Princeton, Distributed Control of Robotic Networks, Princeton University Press,2009.

Reference Books

1. Mikell P, Weiss G.M, Nagel R.N and Odrey N.G, Industrial Robotics, McGraw Hill, New York,1986.
2. Deb S.R, Robotics Technology and Flexible Automation, Tata McGraw Hill, New Delhi, 1994.
3. N. Bostrom, Superintelligence: Paths, Dangers, Strategies, Oxford University Press, 2016.

4. H. Bray, You Are Here: From Compass to GPS, The History and Future of How We Find Ourselves, Basic Books, New York2014.

Course Outcomes*:*

On completion of this course, the students will,

1. Understand robot dynamics and multivariable control.
2. Learn how control theoretic ideas can be extended to design automation systems.
3. Be introduced to the most popular methods for motion planning and obstacle avoidance.
4. Be familiar with robot programming, computer vision, and robotic networks and applications in the industry.

ICPE33 - POWER ELECTRONICS

Course type: Programme Elective (PE) ***Pre-requisites***: -
No. of Credits: 3

Course Objectives:

1. To introduce the students about the theory and applications of power electronic systems for high efficiency, renewable and energy saving conversion systems.
2. To impart knowledge on the characteristics of different power electronics switches, drivers and selection of components for different applications.
3. To teach about the switching behavior and design of the converter, inverter and chopper circuits.
4. To foster the ability to understand the use of power converters in commercial and industrial applications

Course Content:

Power semiconductor switches: SCRs - series and parallel connections, driver circuits, turn-on characteristics, turn off characteristics.

AC to DC converters: Natural commutation, single phase and three phase bridge rectifiers, semi controlled and fully controlled rectifiers, dual converters.

DC to DC converters: Voltage, Current, load commutation, thyristor choppers, design of commutation elements, MOSFET/IGBT choppers, AC choppers.

DC to AC converters: Thyristor inverters, McMurray-Mc Murray Bedford inverter, current source inverter, voltage control, inverters using devices other than thyristors, vector control of induction motors.

AC to AC converters: Single phase and three phase AC voltage controllers, integral cycle control, single phase cyclo-converters - effect of harmonics and Electro Magnetic Interference (EMI).

Applications in power electronics: UPS, SMPS and Drives.

Text Books:

1. Rashid M. H, Power Electronics - Circuits, Devices and Applications, Prentice Hall, New Delhi, 4thEdition, 2013.
2. Dubey G. K, Doradla S.R, Joshi and Sinha R.M, Thyristorised Power Controllers, New Age International Publishers, New Delhi, 2010.
3. John G. Kassakian, Principles of Power electronics, Addison Wesley, 1991.
4. P. S. Bimbhra, Power Electronics, Khanna Publishers, 5th Edition, 2012.

Reference Books:

1. Vedam Subramanyam K, Power Electronics, New Age International Publishers, New Delhi, 2^{nd} Edition, 2012.
2. Mohan, Undeland and Robbins, Power Electronics: Converters, Applications and Design, John Wiley and Sons, New York, 3^{rd} Edition, 2007.
3. Joseph Vithyathil, Power Electronics, McGraw Hill, New York, 1995.

Course Outcomes:

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

1. Work professionally in the area of power and power related fields.
2. Have good understanding of the basic principles of switch mode power conversion.
3. Apply knowledge of mathematics and engineering and identify formulas to solve power and power electronics engineering problems.
4. Choose appropriate power converter topologies and design suitable power stage and feedback controllers for various applications like microprocessor power supplies, renewable energy systems and control of motor drives.

ICPE34 - DIGITAL SIGNAL PROCESSING

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC15
No. of Credits: 3

Course Objectives:

1. To provide higher level of understanding of discrete-time and digital signal in time and frequency domains.
2. To provide knowledge to analyze linear systems with difference equations
3. To design and implement different structures of FIR and IIR filters.
4. To introduce about DSP processors and FFT processors.

Course Content:

Signal Processing Fundamentals: Discrete-time and digital signals, A/D, D/A conversion and Nyquist rate, Frequency aliasing due to sampling, Need for anti-aliasing filters. Discrete Time Fourier transform and frequency spectra, Spectral computation, Computational complexity of the DFT and the FFT, Algorithmic development and computational advantages of the FFT, Inverse FFT, Implementation of the FFT, Correlation of discrete-time signals.
Discrete-time systems, Difference equations and the Z-transform, Analysis of discrete-time LTIL systems, Stability and Jury's test.

FIR Filters: Ideal digital filters, Realizability and filter specifications, Classification of linear phase FIR filters, Design using direct truncation, window methods and frequency sampling, Least-squares optimal FIR filters, Minimax optimal FIR filters, Design of digital differentiators and Hilbert transformers, comparison of design methods.

IIR Filters: Design of analog prototype filters, Analog frequency transformations, Impulse invariance method and digital frequency transformations, Bilinear transformation, Analog prototype to digital transformations, Difficulties in direct IIR filter design, Comparisons with FIR filters.

Filter Realization: Structures for FIR filters, Structures for IIR filters, State-space analysis and filter structures, fixed point and floating-point representation of numbers, Errors resulting from rounding and truncating, Quantization effects of filter coefficients, Round-off effects of digital filters.

DSP Processors: Computer architectures for signal processing – Harvard architecture and pipelining,General purpose digital signal processors, Selection of DSPs, Implementation of DSP algorithms on a general purpose DSP, Special purpose hardware – hardware digital filters and hardware FFT processors, Evaluation boards for real-time DSP.

Text Books:

1. Chen, C.T., Digital Signal Processing: Spectral Computation and Filter Design, Oxford Univ. Press,2001.
2. Proakis, J.G., Manolakis, D.G., Digital Signal Processing: Principles, Algorithms, and Applications,Prentice Hall of India, 3rd Edition, 2007.
3. Ifeachor, E.C., and Jervis, B.W., Digital Signal Processing: A Practical Approach, Pearson EducationAsia, 2nd Edition, 2009.

Reference Books:

1. McClellan, J.H., Schafer, R.W., and Yoder, M.A., DSP First: A Multimedia Approach, Prentice HallUpper Saddle River, NJ, 2nd Edition, 2003.
2. Mitra, S.K., Digital Signal Processing: A Computer-Based Approach, McGraw Hill, NY, 4th Edition, 2011.
3. Embree, P.M., and Danieli, D., C++ Algorithms for Digital Signal Processing, Prentice Hall UpperSaddle River, NJ, 2nd Edition, 1999.

Course Outcomes:

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

1. Analyze the signals in both time and frequency domain
2. Design FIR and IIR filters for signal pre-processing
3. Implement and realize the filters using different structures.
4. Explain the selection of DSP processor for signal processing applications.

ICPE35 - INDUSTRIAL ELECTRIC DRIVES

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPE33
No. of Credits: 3

Course Objectives:

1. To introduce to the students on the concept of employing power convertors for the design of electric drives.
2. To impart knowledge on the analysis of electric drive system dynamics.
3. To apply the knowledge of drives to choose the right solid-state drive for a given application.
4. To impart knowledge on the design and development of control methods for electric drive systems.

Course Content:

Electric Drive System - Dynamics and steady state stability

Components of electrical Drives – electric machines, power converter, controllers - dynamics of electric drive - torque equation - equivalent values of drive parameters - components of load torques types of load - four quadrant operation of a motor — steady state stability – load equalization – classes of motor duty-determination of motor rating

DC motor drives – dc motors and their performance (shunt, series, compound, permanent magnet motor, universal motor, dc servomotor) – braking – regenerative, dynamic braking, plugging –Transient analysis of separately excited motor – converter control of dc motors – analysis of separately excited and series motor with 1-phase and 3-phase converters – dual converter –analysis of chopper controlled dc drives – converter ratings and closed loop control – transfer function of self, separately excited DC motors – linear transfer function model of power converters – sensing and feeds back elements – current and speed loops, P, PI and PID controllers – response comparison – simulation of converter and chopper fed DC drive.

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 – effect of harmonics and control of harmonics.

PWM inverter drives for Induction Motors – multi quadrant drives – rotor resistance control – slip torque characteristic – torque equations, constant torque operation – slip power recovery scheme – torque equation – torque slip characteristics – power factor – methods of improving power factor – limited sub synchronous speed operation – super synchronous speed operation.

Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors – principles of synchronous motor control – voltage source inverter drive with open loop control – self-controlled synchronous motor with electronic commutation – self -controlled synchronous motor drive using load commutated thyristor inverter.

Text Books:

1. R. Krishnan, Electrical Motor Drives, PHI-2003.
2. G.K. Dubey, Power semiconductor-controlled drives, Prentice Hall- 1989.
3. G.K. Dubey, Fundamentals of Electrical Drives, Narosa- 1995.
4. S.A. Nasar, Boldea, Electrical Drives, Second Edition, CRC Press – 2006.
5. M. A. ElSharkawi, Fundamentals of Electrical Drives, Thomson Learning.2nd edition 2019.

Reference Books:

1. W. Leohnard, Control of Electric Drives, Springer- 2001.
2. Murphy and Turnbull, Power Electronic Control of AC motors, Pergamon Press.
3. Vedam Subrahmaniam, Electric Drives, TMH-2nd edition 2017.
4. G. K. Dubey, Power semiconductor-controlled drives, Prentice Hall – 1989.

Course Outcomes:

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

1. Design suitable power electronic circuit for an electric drive system
2. Analyse the dynamics and steady state stability of motors
3. Select appropriate control method for the electric drives.
4. Select a suitable electric drive for a particular industrial application.

ICPE36 - REAL-TIME EMBEDDED SYSTEMS

Course type: Programme Elective (PE) ***Pre-requisites*:** **ICPC18**

No. of Credits: 3

Course Objectives:

1. To introduce the basic concepts of Embedded Systems
2. To expose to the design principles of advanced level ARM processors.
3. To provide basic understanding of the concepts of OS and RTOS.
4. To develop the embedded systems for real time system

Course Content:

Embedded system architecture and classifications, challenges, choice and selection of microcontrollers for embedded systems design. ARM Processor – Evolution, Architecture versions, Processor Families, Instruction Set – ARM state and Thumb state instructions, Software development tools.

ARM Cortex Architecture, Programming: Internal blocks – Processor core features, system peripherals, Memory map, bus system, debug support, User Peripherals, Serial Interfaces, Programming the peripherals using C – examples. Case studies of hardware design and software development.

OS Concepts and types, tasks and task states, process, threads, inter process communication, task synchronization, semaphores, role of OS in real time systems, scheduling, resource allocation, interrupt handling, other issues of RTOS. Examples of RTOS. Working with RTOS with ARM Cortex embedded controllers

Text Books:

1. Johnathon M Valvano, Embedded Systems: Introduction to ARM Cortex M Microcontrollers, 5th Edition, 2017
2. Johnathon M. Valvano, Real Time Operating Systems for ARM Cortex M Microcontrollers, 4th Edition, 2017
3. Joseph Yiu, The Definitive Guide to ARM Cortex M3 and ARM Cortex M4 Processors, 1st Edition, 2014

Reference Books:

1. Cortex M4 Technical Reference Manual: ARM Rev r0p0 ,2010.
2. ARMv7-M Architecture Reference Manual.2019

Course Outcomes:

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

1. Design an embedded system for simple applications.
2. Develop applications using embedded ‘C’ language.
3. Understand RTOS structure and types
4. Develop the real time embedded systems

ICPE37 – SMART AND WIRELESS INSTRUMENTATION

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To expose to the basics of sensors used in industries.
2. To provide adequate knowledge on smart instrumentation and wireless sensor networks.
3. To impart knowledge on various standard protocols used in wireless instrumentation.
4. To apply the knowledge of sensors, transceivers, controllers and power supplies to implement a WSN for arequired application.

Course Content:

Sensor Classification-Thermal sensors -Humidity sensors -Capacitive Sensors-Planar Inter digital Sensors-Planar Electromagnetic Sensors-Light Sensing Technology-Moisture Sensing Technology-Carbon Dioxide (CO2) sensing technology-Sensors Parameters

Frequency of Wireless communication -Development of Wireless Sensor Network based Project-Wireless sensor based on microcontroller and communication device-Zigbee Communication device.

Power sources- Energy Harvesting –Solar and Lead acid batteries-RF Energy /Harvesting-Energy Harvesting from Vibration-Thermal Energy Harvesting-Energy Management Techniques-Calculation for Battery Selection

Brief description of API mode data Transmission-Testing the communication between coordinator and remote XBee-Design and development of graphical user interface for receiving sensor data using C++;
A brief review of signal processing techniques for structural health monitoring.

WSN based physiological parameters monitoring system- Intelligent sensing system for emotion recognition-WSN based smart power monitoring system. Digital light processor (DLP)

Text Books:

1. Subhas Chandra Mukhopadhyay, Smart Sensors, Measurement and Instrumentation, Springer Heidelberg,New York, Dordrecht London, 2013.
2. Halit Eren, Wireless Sensors and Instruments: Networks, Design and Applications, CRC Press, Taylor andFrancis Group, 2006.

Reference Books:

1. Uvais Qidwai, Smart Instrumentation: A data flow approach to Interfacing, Chapman and Hall, 1st Edition,2013.

Course Outcomes:

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

1. Understand about smart instrumentation system
2. Acquire knowledge on ZigBee transceivers
3. Design self-diagnosing instrumentation system.
4. Identify the issues in power efficient systems and implement energy management techniques in WSN
5. Design wireless instrumentation systems for the given requirement.

ICPE38 - PRINCIPLES OF COMMUNICATION SYSTEMS

Course type: Programme Elective (PE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To introduce the concept of communication systems.
2. To understand the need for modulation.
3. To impart knowledge in the different methods of analog and digital communications and their significance.
4. To make students familiar with various sources of noise and its characteristics.

Course Content:

Modulation - need for modulation. Principles of amplitude modulation: modulation and demodulation of AM,DSBSC, SSB signals, VSB and FDM systems. AM transmitter and Receiver. Essence of industrial data communication.

Principles of angle modulation: frequency and phase modulation, narrow and wide band FM, generation and demodulation of FM signals. FM transmitter and Receiver.

Pulse modulation systems- Sampling theorem, Pulse Amplitude Modulation (PAM), Pulse width modulation(PWM), Pulse time modulation (PTM): PDM and PPM. TDM systems.

Pulse code modulation- Pulse Code Modulation - quantization - PCM systems- DPCM and Delta modulation.Digital modulation schemes: ASK-PSK-FSK-Generation and detection

Noise-Source and classification, atmospheric noise, thermal noise and shot noise. Noise equivalent bandwidth, noisefigure and equivalent noise temperature of a two-terminal network.

Text Books:

1. S. Haykin, Communication Systems, John Wiley and Sons, 4th Edition, 2000.
2. H. Tauband D. Schilling, Principles of Communication System, Tata McGraw Hill, 4th Edition, 2017
3. J.S. BeasleyandG.M. Miler, Modern Electronic Communication, Prentice-Hall, 9th Edition, 2008.

Reference Books:

1. B.P. Lathi, Modern Analog and Digital Communication systems, Oxford University Press, 3rd Edition, 2007
2. B. Carlson, Communication Systems, McGraw Hill Book Co., 5th Edition, 1986.
3. Sam Shanmugam, Digital and analog Communication Systems, John Wiley, 2012.
4. John G. Proakis, Masoud Salehi - Fundamentals of Communication Systems, 2nd Edition, Pearson, 2014.

Course outcomes:

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

1. Explain the basic concepts of communication systems.
2. Establish understanding of various analog modulation techniques and demodulation techniques.
3. Understand various analog pulse modulation techniques and demodulation
4. Understand digital pulse modulation and digital modulation techniques and calculate capacity
5. Describe different types of noise and calculate the noise equivalent bandwidth and noise figure of a two-portnetwork.

ICPE39 - MULTISENSOR DATA FUSION

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To introduce the fundamentals of data fusion and multisensor data fusion
2. To expose the students to the different techniques used in sensor data fusion.
3. To impart skills needed to develop and apply data fusion algorithms.
4. To expose the students, the state of the art in multi sensor/ source integration, target tracking and identification.

Course Content:

Multisensor data fusion: Introduction, sensors and sensor data, 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, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta - heuristics.
Taxonomy of algorithms for multisensor data fusion. Data association. Identity declaration.

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

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 indata structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system.

Text Books:

1. David L. Hall, Sonya A H McMullen, Mathematical techniques in Multisensor data fusion, Artech House,Boston, 2nd Edition, 2004.
2. R.R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, PrenticeHall Inc., New Jersey, 1998.
3. Jitendra R. Raol, Multi sensor data fusion with MATLAB, CRC Press, 2010.

Reference Books:

1. Arthur Gelb, Applied Optimal Estimation, M.I.T. Press, 1982.
2. James V. Candy, Signal Processing: The Model Based Approach, McGraw –Hill Book Company, 1987.

Course Outcomes:

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

1. Understand the importance of data fusion
2. Identify and characterise the principle components of data fusion and information systems.
3. Apply the concepts of data fusion in sensing.
4. Select fusion techniques appropriate to system and mission needs.

ICPE40 - DIGITAL IMAGE PROCESSING

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To introduce the fundamentals of image processing
2. To introduce to the concept of image restoration and reconstructions
3. To introduce the concepts of image segmentation and compressions
4. To impart knowledge on the design and realization of various image processing algorithms.

Course Content:

Introduction and Digital Image Fundamentals:
Introduction to image processing, origin, examples of fields, steps in image processing, components of image processing system, digital image fundamentals – elements of visual perception, light and electromagnetic spectrum, image sensing and acquisition, mathematical tools used in image processing.

Intensity Transformations, Spatial Filtering and Filtering in frequency domain:
Basics intensity transformation functions, histogram processing, fundamentals of spatial filtering, smoothing and sharpening spatial filtering, combinations of image enhancement method, filtering in the frequency domain – Fourier transform of sample functions, DFT of one variable, extension to two variables, properties of 2 D DFTs, selective filtering, realization of FDT, FFT, filter design aspects.

Image Restoration and Reconstruction:
Model of the image degradation / restoration process, noise models, restoration in the presence of noise only – spatial filtering, periodic noise reduction by frequency domain filtering, estimating the degradation functions, inverse filtering, image reconstruction from projections.

Image Segmentation:
Image segmentation - point, line and edge detection, Thresholding, Regions Based segmentation, segmentation using morphological watersheds, usage of motion in segmentation, edge linking and boundary detection, Hough transform, chain codes, boundary segments, skeletons, boundary descriptors, Fourier descriptors.

Image Compression:
Image compression - image compression - data redundancies elements of information, variable-length coding, predictive coding, transform coding, image compression standards, wavelets and multi-resolution processing - image pyramids, sub-band coding.

Object Recognition and Case studies:
Object Recognition- patterns and pattern classes, recognition based on decision – theoretic methods,structural methods, case studies – image analysis

Text Books:

1. Gonzalez and Woods, Digital Image Processing, Pearson education, 3^{rd} Edition, 2008.
2. Jain Anil K., Fundamentals Digital Image Processing, Prentice Hall India, 2010.

Reference Books:

1. Milan Sonka, Vaclav Hlavav, Roger Boyle, Image Processing, Analysis and Machine Vision, Thomson Learning, 2^{nd} Edition, 2001.
2. Rangaraj M. Rangayyan, Biomedical Image Analysis, CRC Press, 2005.
3. Pratt W.K, Digital Image Processing, John Wiley and Sons, 3^{rd} Edition, 2007.

Course Outcomes:

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

1. Understand the importance of image processing
2. Perform image restoration and reconstruction
3. Perform image segmentation and compressions
4. Design, realize and troubleshoot various algorithms for the case studies based on image processing.

ICPE41- BIO MEDICAL SIGNAL PROCESSING

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives

1. To expose the students to the importance of biomedical signals and analysis
2. To introduce different types of bio signals and their characteristics
3. To study different noise removal mechanisms for biomedical signals
4. To analyse the signals using time and frequency domain measures

Course Content

Introduction to signals, Continuous time and discrete time signals and LTI systems, Introduction and properties of Fourier transform, Laplace transform and Z-transform

Nature of biomedical signals; origin and dynamics of electroneurogram (ENG), electromyogram (EMG), electrocardiogram (ECG), electroencephalogram (EEG), event related potentials (ERP), electrogastrogram (EGG), phonocardiogram (PCG), vibromyogram (VMG) and vibroarthogram (VAG), Objectives of biomedical signal analysis and difficulties in biomedical signal analysis

Random, structured and physiological noise, noises and artefacts in ECG, EMG and EEG signals, Filtering for removal of artefacts; Introduction to filter design; Time domain filters, Frequency domain filters, and optimal filters and selection of appropriate filters

Event detections in ECG, EEG and heart sounds, Analysis of wave shape and waveform complexity, QRS complex, analysis of ERPs and analysis of electrical activity using time and frequency domain measures

Analysis of nonstationary and multicomponent signals, heart sound and murmurs, EEG rhythms and waves and case studies

Text Books

1. Rangayyan, R. M. (2015). Biomedical signal analysis (2nd Edition). Wiley-IEEE Press. ISBN: 0470911396(Online ISBN 1119068129).
2. Eugene N. Bruce, Biomedical Signal Processing and Signal Modeling, A Wiley-Interscience Publication JOHNWILEY and SONS, INC. ISBN 0-471-34540-7.2001
3. B.P. Lathi, Principles of Linear Systems and Signals, Oxford University Press, 2nd Edition, 2009

Reference Books

1.Le Cerutti, S., and Marchesi, C. (Eds.). (2011). Advanced methods of biomedical signal processing (Vol. 27). JohnWiley and Sons.
2. Webster, J. G. (2009). Medical instrumentation application and design. John Wiley and Sons.
3. Mitra, S.K., Digital Signal Processing: A Computer-Based Approach, McGraw Hill, NY, 4th Edition, 2011

Course outcomes

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

1. understand the issues associated with the interpretation of biomedical signals
2. familiar with different signals such as ECG, EMG and EEG
3. able to remove the noises in bio signals by selecting appropriate filters
4. implement appropriate signal processing methods to extract reliable information

ICPE42 – MEDICAL IMAGING SYSTEMS

Course type: Programme Elective (PE) ***Pre-requisites*:**
No. of Credits: 3

Course Objectives

1. To introduce the methods of medical imaging.
2. To impart knowledge in the physics behind the various imaging techniques.
3. To teach the construction and working of various imaging techniques.
4. To study the methods of image reconstruction

Course Content

Introduction to image processing in medical applications, X-Ray tubes, cooling systems, removal of scatters, Fluoroscopy- construction of image Intensifier tubes, angiographic setup, mammography, digital radiology, DSA.

Need for sectional images, Principles of sectional scanning, CT detectors, Methods of reconstruction, Iterative, Back projection, convolution and Back-Projection. Artifacts, Principle of 3D imaging

Alpha, Beta and Gamma radiation, Radiation detectors, Radio isotopic imaging equipments, Radio nuclides for imaging, Gamma ray camera, scanners, Positron Emission tomography, SPECT, PET/CT.

Wave propagation and interaction in Biological tissues, Acoustic radiation fields, continuous and pulsed excitation, Transducers and imaging systems, Scanning methods, Imaging Modes, Principles and theory of image generation.

NMR, Principles of MRI, Relaxation processes and their measurements, Pulse sequencing and MR image acquisition, MRI Instrumentation, Functional MRI.

Text Books

1. D.N. Chesney and M.O. Chesney, Radio graphic imaging, CBS Publications, New Delhi, 4^{th} Edition, 2005.
2. Dwight G. Nishimura, Lulu, Principles of Magnetic Resonance Imaging, StanfordUniv,2010
3. Flower M.A., Webb's Physics of Medical Imaging, Taylor and Francis, New York, 2^{nd}Edition, 2012.
4. Prince and Links, Medical Imaging Signals and Systems, 2nd Edition, Pearson,2015

Reference Books

1. Rangaraj M. Rangayyan, Biomedical Image Analysis, CRC Press, Boca Raton, FL,2005.
2. Donald W. McRobbice, Elizabeth A. Moore, Martin J. Grave and Martin R. Prince, MRI from picture to proton, Cambridge University press, New York, 2^{nd} Edition,2007.
3. Kavyan Najarian and Robert Splinter, Biomedical signals and Image processing, CRC press, New York, 2^{nd} Edition, 2012.

4. Jerry L. Prince and Jonathan M. Links, Medical Imaging Signals and Systems- Pearson Education Inc., 2nd Edition,2014.

Course Outcomes

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

1. Acquire basic domain knowledge about the various medical imaging techniques.
2. Understand the construction and working of various medical imaging equipments.
3. Provide a foundational understanding of algorithms used in medical imaging
4. Analyze the medical images for diagnosis.

ICPE43 - ENERGY HARVESTING TECHNIQUES

Course Type: Programme Elective (PE) ***Pre-requisites:*** -
No of credit: 3

Course Objectives:

1. To introduce basic energy harvesting techniques using smart materials and structures and combining with mechanisms.
2. To impart knowledge in the design of power converter circuits for ambient energy harvesters.
3. To introduce mathematical modelling of piezoelectric based energy harvesters.
4. To introduce on certain case studies.

Course Content:

Energy Harvesting Basics, Analysis of ambient energy- Vibration, shock, wind, Thermal, RF, energy transducers- electromagnet, photovoltaic, piezoelectric and other smart materials- working principle, equivalent circuit models.

Vibrational energy harvesting- Electromechanical Modelling of Cantilevered Piezoelectric Energy Harvester for Persistent Base Motion-lumped parameter model, correction factors, coupled distributed parameter model, modelling assumptions, closed form solution for unimorph and bimorph configuration, harvesting techniques for broadband excitation

Piezoelectric energy harvesting circuits-low power rectifier circuits with resistive, linear and nonlinear reactive input impedance, piezoelectric pre-biasing, self-tuning, DC-DC switch mode converters, impedance matching circuits for maximum output power.

Electromagnetic energy harvesting- Wire wound coil properties, micro fabricated coils, magnetic materials, scaling of electromagnetic vibration generators and damping, maximizing power from an EM generator, micro and macro scale implementation.

Thermoelectric Energy harvesting- Harvesting Heat, thermoelectric theory, thermoelectric generators andits efficiency, matched thermal resistance, heat flux, design consideration, optimization for maximum output, matching thermoelectric to heat exchangers- thin film devices.

Case study- harvester driven by muscle power, knee joint movement harvesting, etc. strategies to improve energy conversion efficiency for different ambient sources.

Text Books:

1. Shashank Priya and Daniel J. Inman, Energy Harvesting Technologies, Springer-Verlag New York, Inc., 1st Edition, 2010.
2. Danick Briand, Eric Yeatman, and Shad Roundy, Micro energy Harvesting, Wiley-VCH Verlag GmbH and Co, 2015.

Reference Books:

1. Stephen Beeby, Neil white, Energy Harvesting for Autonomous Systems, Artech house, Norwwood,1st Edition ,2010.
2. Alper Erturk and Daniel J Inman, Piezoelectric Energy Harvesting, John Wiley and Sons.Ltd.1st Edition ,2011.
3. Tom J. Kazmiershi, Steve Beeby, Energy Harvesting System, Principles, Modelling and Application, springer, New York, 2011.

Course Outcomes:

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

1. Comprehend in the concept of various ambient energy harvesting techniques.
2. Design optimal power converting circuits for different harvesters.
3. Design vibration energy harvester for narrow and wide band excitation.
4. Design electromagnetic and thermoelectric based energy harvesters.
5. Apply the energy harvesting concepts to common engineering problems.

ICPE44 – SMART MATERIALS AND SYSTEMS

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To familiarize the students with the different smart materials and their characteristics.
2. To expose the students to understand the functionalities through the mathematical equations.
3. To teach the students about the significant features of smart materials in sensing, actuation and control.
4. To teach the students to design and develop smart structures using smart material-based actuators and sensors.

Course Content:

Introduction to Smart Materials and Structures: smart materials for sensing and actuation, the role of Smart Materials in developing Intelligent Systems and Adaptive Structures. Piezoelectric Materials: constitutive relationship, electromechanical coupling coefficients, piezoelectric constants, piezoceramic materials, variation of coupling coefficients in hard and soft piezoceramics, polycrystalline vs single crystal piezoelectric materials, polyvinyldene fluoride, piezoelectric composites.

Actuators and Sensor based on Piezoelectric Materials: Induced Strain actuation model, Unimorph and Bimorph Actuators, Actuators embedded in composite laminate, Impedance matching in actuator design, Feedback Control, Pulse Drive, Resonance Drive, Piezoelectric as a Sensor and its applications.

Magnetostrictive Materials – constitutive relationship, magneto-mechanical coupling coefficients, Joule Effect, Villari Effect, Matteuci Effect, Wiedemann effect, Giant magnetostriction in Terfenol-D, Terfenol-D particulate composites, Galfenol and Metglas materials. Magnetostrictive Mini Actuators, Thermal instabilities, discretely distributed actuation, Manetostrictive Composites. Magnetostrictive Sensors

Shape Memory Alloys (SMA) – Phase Transformations, Basic Material Behavior and Modelling Issues, A Comprehensive Model for Uniaxial Stress, Properties of SMAs for Biomedical Applications Shape Memory Alloy based actuators for Shape Control. Electro-active Polymers (EAP): Electro-active Polymers for Work-Volume Generation, EAP as actuator and sensor. Electro-Rheological (ER) fluids, Magneto- Rheological (MR) fluids.

Integration of Smart Sensors and Actuators to Smart Structures – Optimal Placement of Sensors and Actuators, Design of Controller for Smart Structure, Techniques of Self-Sensing using piezoelectric and SMA, SMA based encoders, micro robotics, micro devices. Case Studies to Advanced Smart Materials: Active Fiber Composites (AFC), Energy Harvesting Actuators and Energy Scavenging Sensors, Self- healing Smart Materials

Text Books:

1. Mukesh V Gandhi, Brian S Thompson, Smart Materials and Structures, Chapman and Hall Publishers, 1st Edition, 1992.
2. Mel Schwartz, Encyclopaedia of smart materials, John Wiley and Sons, 1st Edition,2002.
3. Srinivasan A.V., Michael McFarland D., Smart Structures Analysis and Design, Cambridge University Press, 1st Edition, 2010.
4. Culshaw B., Smart structures and Materials, Artech house, 1st Edition, 2004.
5. Leo, D.J. Engineering Analysis of Smart Material Systems, John Wiley and sons, 1st Edition 2008.
6. R.C. Smith, smart material systems: model development, frontiers in applied mathematics, SIAM, 2005.
7. H. Janocha, Adaptronics and smart structures: Basics, Materials, Design, and Applications, springer, 2nd Edition, 2007.

Reference Material:

1. www.iop.org/sms
2. http:jim.sagepub.com.

Course Outcomes:

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

1. Acquire knowledge about the smart materials, their characteristics and design aspects.
2. Design, model and control smart materials-based structures/systems, through simulation and experimentation.
3. Choose appropriate smart materials for sensing and actuation.
4. Analyze and design techniques, to offer solutions to industrial problems using smart materials.

ICPE45 - HYDRAULICS AND PNEUMATICS

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To provide an understanding of the working of hydraulic and pneumatic systems.
2. To provide an understanding of energy transfer in hydraulic actuators and motors
3. To provide knowledge about controlling components of hydraulic and pneumatic systems.
4. To provide knowledge of design of hydraulic and pneumatic systems and analyze them.

Course Content:

Introduction to Hydraulic Power: Pascal's law and problems on Pascal's Law, continuity equations, Introduction to conversion of units, Structure of Hydraulic Control System. The Source of Hydraulic Power: Pumps Pumping theory, pump classification, gear pumps, vane pumps, piston pumps, pump performance, pump selection. Variable displacement pumps. Hydraulic Actuators: Linear Hydraulic Actuators [cylinders], Mechanics of Hydraulic Cylinder loading.

Hydraulic Motors: Hydraulic Rotary Actuators, Gear motors, vane motors, piston motors, Hydraulic motor theoretical torque, power and flow rate, hydraulic motor performance. Control Components in Hydraulic Systems: Directional Control Valves – Symbolic representation, Constructional features, pressure control valves – direct and pilot operated types, flow control valves.

Hydraulic Circuit Design and Analysis: Control of single and double – acting hydraulic cylinder, regenerative circuit, pump unloading circuit, counter balance valve application, hydraulic cylinder sequencing circuits. Cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, Accumulators. Maintenance of Hydraulic Systems: Hydraulic oils; desirable properties, general type of fluids, sealing devices, reservoir system, filters and strainers, problem caused by gases in hydraulic fluids, wear of moving parts due to solid particle contamination, temperature control, trouble shooting.

Introduction to Pneumatic Control: Choice of working medium, characteristics of compressed air. Structure of pneumatic control system. Compressed air: Production of compressed air – compressors, preparation of compressed air- Driers, filters, regulators, lubricators, distribution of compressed air. Pneumatic Actuators: Linear cylinders – types, conventional type of cylinder working, end position cushioning, seals, mounting arrangements applications.

Directional Control Valves: Symbolic representation as per ISO 1219 and ISO 5599. Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve. Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling, use of quick exhaust valve. Signal Processing Elements: Use of Logic gates – OR and AND gates pneumatic applications, practical examples involving the use of logic gates, Pressure dependent controls types construction– practical applications, time dependent controls – principle, construction, practical applications.

Text Books:

1. Anthony Esposito, Fluid Power with applications, Pearson education, Inc., 5th Edition, 2000.
2. Andrew Parr, Pneumatics and Hydraulics, Jaico Publishing Co. 2000.
3. Dr. Niranjan Murthy and Dr.R.K. Hegde, Hydraulics and Pneumatics, Sapna Publications, 2013.
4. Majumdar S.R., Oil Hydraulics Systems - Principles and Maintenance, Tata McGraw-Hill, 2001.
5. Majumdar, S.R., Pneumatic Systems – Principles and Maintenance, Tata McGraw Hill, 2007.

Reference Books:

1. Srinivasan. R, Hydraulic and Pneumatic Control, Tata McGraw - Hill Education, 2nd Edition, 2012.
2. Shanmugasundaram K, Hydraulic and Pneumatic controls, ChandandCo,2006.

Course Outcomes:

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

1. Acquire knowledge about working of hydraulic and pneumatic systems.
2. Identify the controlling components of hydraulic and pneumatic systems.
3. Select and prepare a distribution system for compressed air.
4. Compile the design of hydraulic and pneumatic systems and analyze them.
5. Demonstrate the need of pressure and time dependent controls.

ICPE46 – ENGINEERING MECHANICS

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To introduce the fundamentals of mechanics and machines to the instrumentation and control engineeringstudents.
2. To explain the application of basic mechanical science concepts
3. To apply different physical principles to the analysis of mechanics and machines
4. To identify the different element of a mechanical system and write the mathematical equations for them.

Course Content:

Forces and equilibrium – Free body diagram – Forces in equilibrium. Stress and strain – Poisson's ratio – Bulk modulus. Beams – Types of beams – Bending moment and shearing force – Bending stresses. Torsion – Torsion of circular shafts – Transmission of power.

Strain energy – Dynamic loading – Strain energy due to shear – Impact torsional loading –Strain energy due to bending – Impact loading of beams.

Linear and angular motion – Linear motion – Curvilinear motion – Relative velocity – Angular motion – Torque and angular motion – Balancing of rotational masses – Momentum – Work and energy.

Mechanisms – Velocity diagrams – Acceleration diagrams. Coriolis acceleration. Flywheels. Machines – Transmission of rotational motion. Geared systems – Gear trains. Friction – Friction clutches. Bearings. Belt drives. Gyroscopic motion – Gyroscopic couple.

Free vibrations – Simple harmonic motion. Linear and torsional vibrations of an elastic system. Transverse vibrationsof beams – Whirling of shafts.

Damped and forced oscillations – Free oscillations – Damped oscillations – Undamped forced oscillations – Damped forced oscillations.

Degrees of freedom – Two rotor system – Forced vibrations.

Text Books:

1. Bolton WC, Mechanical Science, Wiley-Blackwell Publishing, 3rd Edition. 2006.
2. R. C. Hibbeler, Engineering Mechanics - Statics, Pearson Education Inc. 14th Edition. 2015.
3. R. C. Hibbeler, Engineering Mechanics - Dynamics, Pearson Education Inc. 14th Edition 2015.

Reference Books

1. Timoshenko and Young, Engineering Mechanics, McGraw-Hill Book Company, 4th Edition, 1956.

Course outcomes:

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

1. Analyze simple mechanisms and their principles of operation.
2. Write the mathematical equations for static and dynamic loading in simple mechanical systems.
3. Write the equations for energy and power in simple mechanical systems.
4. Analyze free and forced oscillations in simple dynamic systems.

ICPE47 – INTERNET OF THINGS SYSTEM DESIGN

Course type: Programme Elective (PE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives:

1. To provide a good understanding of Internet of Things (IoT) and its envisioned deployment domains.
2. To provide an understanding of smart sensors/actuators with their internet connectivity for experimentation and designing systems.
3. To provide a overview about the various protocol standards deployed in the Internet of Things (IoT) domain and to make informed choices.
4. To impart knowledge in the design and development of IoT systems with enablement ensuring security and assimilated privacy.

Course Content:

Introduction to Internet of Things: Overview of Internet of Things- the Edge, Cloud and the Application Development, Anatomy of the Thing, Industrial Internet of Things (IIoT - Industry 4.0), Quality Assurance, Predictive Maintenance, Real Time Diagnostics, Design and Development for IoT, Understanding System Design for IoT, Design Model for IoT.

System Design of Connected Devices: Embedded Devices, Embedded Hardware, Connected Sensors and Actuators, Controllers, Battery Life Conservation and designing with Energy Efficient Devices, SoCs, CC3200, Architecture, CC3200 Launchpad for Rapid Internet Connectivity with Cloud Service Providers.

Understanding Internet Protocols: Simplified OSI Model, Network Topologies, Standards, Types of Internet Networking – Ethernet, Wi-Fi, Local Networking, Bluetooth, Bluetooth Low Energy (BLE), Zigbee,6LoWPAN, Sub 1 GHz, RFID, NFC, Proprietary Protocols, SimpliciTI, Networking Design – Push, Pull and Polling, Network APIs.

System Design Perspective for IoT – Products vs Services, Value Propositions for IoT, Services in IoT, Design views of Good Products, Understanding Context, IoT Specific Challenges and Opportunities.

Advances Design Concepts for IoT – Software UX Design Considerations, Machine Learning and Predictive Analysis, Interactions, Interusability and Interoperability considerations, Understanding Security in IoT Design, Design requirements of IoT Security Issues and challenges, Privacy, Overview of Social Engineering.

Text Books:

1. Joe Biron andJonathan Follett, Foundational Elements of an IoT Solution – The Edge, The Cloud andApplication Development, Oreilly,1st Edition, 2016.
2. Designing Connected Products, Elizabeth Goodman, Alfred Lui, Martin Charlier, Ann Light, Claire Rowland,1st Edition.

3. The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, Lucas Darnell, 2016.

Reference Books:

1. The Internet of Things – Opportunities and Challenges http://www.ti.com/ww/en/internet_of_things/pdf/14-09-17-IoTforCap.pdf
2. Single Chip Controller and Wi-Fi SOC http://www.ti.com/lit/ds/symlink/cc3200.pdf
3. Wireless Connectivity Solutions http://www.ti.com/lit/ml/swrb035/swrb035.pdf
4. Wireless Connectivity for the Internet of Things – One size does not fit all http://www.ti.com/lit/wp/swry010/swry010.pdf
5. ArshdeepBahga, Vijay Madisetti, Internet of Things –A hands-on approach, Universities Press, 2015.,
6. Raj Kamal, Internet of Things, Architecture and Design Principles, McGraw-Hill, 2017,
7. Marco Schwartz, Internet of Things with the Arduino Yun, Pack Publishing, 2014.

Course Outcomes:

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

1. Understand the design architecture of IoT.
2. Make choice of protocols and deployment in solutions.
3. Comprehend the design perspective of IoT based products /services.
4. Understand the importance of security requirements for IoT design.

ICPE48– SOFTWARE DESIGN TOOLS FOR SENSING AND CONTROL

Course type: Programme Elective (PE) ***Pre-requisites*:** -

No. of Credits: 3

Course Objectives:

1. To expose the students to the software tools available for sensor and control system design.
2. To teach the analytical and numerical modelling of various sensors in macro, meso and micro scale and to study its characteristics through simulation.
3. To expose the students to modelling of physical systems, design and evaluation of various control methods.
4. To expose the students to real time control implementation platforms and to practice on implementation of simple controllers.

Course Content:

Software tools for sensor design: Introduction to history of sensor design software tools, importance and need of software tools. Recent developments in sensor design and analysis software tools. Introduction to COMSOL Multiphysics. Structural Mechanics: Analysis of mechanical structures to static or dynamic loads. Stationary, transient, eigenmode/modal, parametric, quasi-static and frequency-response analysis. Electrical: AC/DC Module for simulating electric, magnetic, and electromagnetic fields in static and low- frequency applications. Design and simulation of sensors and actuators using COMSOL.

Software tools for micro sensor design: Introduction to IntelliSuite, mechanism design, development of sensors and actuators. Introduction to Coventorware, Description of main modules, Architect, Designer, Analyzer and Integrator. System-level and physical-level design approaches. Introduction to meshing and result visualization. Design and simulation of sensors using Coventorware.

Software tools for control design: Introduction to MATLAB, Simulink and Scilab. Introduction to toolboxes. Control design problems using classical control. Control design problems using state space approach.

Implementation of controllers in real time: Introduction to various hardware platforms, control design and implementation for electrical/mechanical/electromechanical/chemical processes using dSPACE, LabVIEW and OPAL-RT.

Text Books:

1. Roger W. Pryor, Multiphysics Modeling Using COMSOL®: A First Principles Approach, Jones and Bartlett Publishers, 1st Edition, 2011.
2. Tamara Bechtold, Gabriela Schrag and Lihong Feng, System-level Modeling of MEMS, Wiley-VCH verlag GmbH and Co, 1st Edition, 2013.
3. Holly Moore, MATLAB for Engineers, Pearson Education, 5th Edition, 2017.
4. Brian Hahn and Daniel Valentine, Essential MATLAB for Engineers and Scientists, Elsevier, Academic press, 6th edition, 2016.

Reference Books:

1. Mehrzad Tabatabaian, COMSOL 5 for Engineers, Mercury Learning and Information, 1^{st} Edition,2015.
2. S R Otto and J P Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer-verlag, 1^{st} Edition,2005.
3. Stephen J Chapman, MATLAB Programming for Engineers, Bookware Companion Series, 5^{th} Edition, 2015.
4. Amos Gilat, MATLAB – An Introduction with Applications, John Wiley and Sons, Inc., 5^{th} Edition,2014.

Course Outcomes:

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

1. Select an appropriate software tools for sensor and actuator design.
2. Design, model and simulate various sensing and actuating mechanisms.
3. Design controller and evaluate its performance through simulation.
4. Design a controller using state space method and evaluate its performance through simulation.
5. Acquire knowledge in the selection and usage of hardware for real time implementation of controllers.

ICPE49 - NEURAL NETWORKS AND FUZZY LOGIC

Course type: Programme Elective (PE) ***Pre-requisites***: -
No. of Credits: 3

Course Objectives:

1. To provide an overview of intelligent techniques.
2. Develop skills to gain a basic understanding of neural network and fuzzy logic theory.
3. To introduce different architectures and algorithms of Neural Networks.
4. To impart knowledge on Fuzzy set theory and Fuzzy rules.

Course Content:

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent technique for real world Engineering applications.

Supervised and Unsupervised Neural networks: Perceptron, Standard back propagation Neural network: Architecture, Algorithm and other issues. Discrete Hopfield's networks, Kohnen's self-organizing maps, adaptive resonance theory (ART1).

Neural networks for control systems: Schemes of Neuro-control, identification and control of dynamical systems, case studies.

Fuzzy set and operations, Fuzzy relations, Fuzzifications, Fuzzy rule-based systems, defuzzification fuzzy learning algorithms.

Fuzzy logic for control system with case studies. Introduction to neuro-fuzzy system and genetic algorithm.

Text Books:

1. Timothy J. Ross, Fuzzy Logic with Engineering Applications, John Wiley and Sons Ltd Publications, 4th edition, 2016.
2. Laurene Fausett, Fundamentals of Neural networks, Pearson education, Eight Impression, 2012.

Reference Books:

1. S. Haykin, Neural Networks: A comprehensive Foundation, Prentice Hall Inc., New Jersey, 2nd Edition,1999.
2. Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, Prentice Hall, New Delhi, 1994.
3. Zdenko Kovacic, Stjepan Bogdan, Fuzzy Controller Design Theory and Applications, CRC Press, 1stEdition, 2006.
4. Satish Kumar, Neural Networks–A classroom approach, Tata McGraw-Hill Publishing Company Limited,2013.

Course Outcomes:

On completion of this course, the students will be,

1. Familiar with the basic concepts of Neural Network and Fuzzy logic.
2. Able to develop Neural Network based modelling and control for different process applications.
3. Able to design Fuzzy logic-based control system for process applications.
4. Able to design hybrid neuro-fuzzy architecture for engineering optimization problems.

ICPE50 - INDUSTRIAL DATA COMMUNICATION

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPE38
No. of Credits: 3

Course Objectives:

This course gives an overview to real-time communication between systems in industries and to adopt suitableprotocol thereby prepare the students to take up challenges in industrial environment.

1. To expose the students to communication systems emerging in the field of instrumentation.
2. To introduce to the system interconnection and protocol standards.
3. To give an overview of HART Protocols
4. To impart knowledge in Field bus and Profi bus protocol

Course Content:

Interface: Introduction, Principles of interface, serial interface and its standards. Parallel interfaces and buses.

Fieldbus: Use of fieldbuses in industrial plants, functions, international standards, performance, use of Ethernetnetworks, fieldbus advantages and disadvantages. Fieldbus design, installation, economics and documentation.

Instrumentation network design and upgrade: Instrumentation design goals, cost optimal and accurate sensor networks. Global system architectures, advantages and limitations of open networks, HART network and Foundationfieldbus network.

PROFIBUS-PA: Basics, architecture, model, network design and system configuration. Designing PROFIBUS-PA and Foundation Fieldbus segments: general considerations, network design.

Text Books:

1. Noltingk B.E., Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.
2. B.G. Liptak, Process software and digital networks, CRC press, Florida, 3rd Edition 2011.

Reference Books:

1. Behrouz Forouzan, Data Communications and Networking, Tata McGraw Hill Education, New Delhi, 2010.
2. Steve Mackay, Edwin Wright, Deon Reynders, John Park, Practical Industrial Data Networks: Design,Installation and Troubleshooting, Newnes, An imprint of Elsevier, 2004.
3. Andrew S. Tanenbaum, David J. Wetherall, Computer Networks, Prentice Hall of India Pvt. Ltd., 5thEdition. 2011

Course Outcomes:

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

1. Explain the rationale behind the technological development of industrial networks.
2. Understand various buses and serial//parallel interface.
3. Exposure to the HART protocol functions and features.
4. Understand and configuration of Field bus and Profibus protocols.
5. Evaluate and select protocol for particular application

ICPE51 - NUMERICAL METHODS

Course type: Programme Elective (PE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives

To introduce

1. Numerical methods for Solving Linear Systems
2. Numerical methods to solve equations of one variable as well as system of equations with two variables.
3. Interpolating Polynomials and best curve fitting methods for the given data.
4. Numerical differentiation and integration
5. Numerical solutions of Ordinary Differential Equations.

Course Content

Digital representation of numbers, Finite precision arithmetic, Machine Precision, Measuring errors, convergence of iterative sequences, Taylor series, Order Notation. Numerical Solution of $(x) = 0$: Bisection method, Secant method, Newton's method, Newton's method for $(x, y) = 0, g(x, y) = 0.$ Order of convergence.

Solution of linear system of equations –Direct method: Gaussian elimination, Gauss-Jordan methods, LU Decomposition method-Crout's method. Algorithm for tri-diagonal system, Iterative method: Jacobi and Gauss-Seidal's method -Sufficient conditions for convergence - Eigen Value problems- Power method.

Interpolation: Lagrange's method, Newton's divided difference, forward and backward difference interpolation method. Least squares fitting of a curve to data-Polynomial curve fitting, exponential curve ($y = ae^{bx}$) fitting to data.

Numerical Differentiation based on interpolation and finite difference. Numerical Integration-Closed and open type integration rules-Trapezoidal rule, Simpson's1/3ruleand3/8 rule, mid-point and two-point rule. Adaptive integration based on Simpson's rule. Gauss quadrature methods, Integrals with infinite limits $_0\int^{\infty} e^{-}(x)dx$).

Numerical solution of ordinary differential equations: Taylor's series method, Single step method- Euler's method, Euler's modified method, Fourth order Runge-Kutta method. Fourth order R-K method for simultaneous equations and 2^{nd} order ODE. Multi step methods:Milne's and Adams method.

Reference Books:

1. Jain, M.K., Iyengar, S.R. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, New Age International, 2012.
2. S.S. Sastry, Introductory methods of numerical Analysis, 4/e, Prentice Hall of India, New Delhi, 2005.
3. David Kincaid and Ward Cheney, Numerical Analysis, 3rd edition, AmericanMathematics Society, (Indian edition) –2010.
4. Gerald, C.F., and Wheatley, P.O., Applied Numerical Analysis, Addison-WesleyPublishing Company,1994.
5. G Dahlquist and A Bjorke, Numerical Methods in Scientific Computing, vol. 1 SIAM,2008

Course Outcomes

On completion of the course, students should be able to

1. Compute numerical solution of given system AX=B by direct and iterative methods.
2. Compute largest eigenvalue and its corresponding eigenvector of matrix A.
3. Compute numerical solution of f(x)=0 and nonlinear equations with two variables,
4. Interpolate function and approximate the function by polynomial.
5. Compute numerical differentiation and integration off(x).
6. Compute best curve fit for the given data by curve fitting method.
7. Compute numerical solution of ordinary differential equations by finite difference method.

ICPE52 - ELECTRON DEVICES AND CIRCUITS

Course type:	Programme Elective (PE)	***Pre-requisites:***	-
No. of Credits:	3		

Course Objectives

1. To provide the structure of basic electronic devices
2. To introduce the active and passive circuit elements.
3. To provide the operation and applications of transistor like BJT and FET.
4. To learn the characteristics of amplifier, gain and frequency response.
5. To introduce the functionality of positive and negative feedback systems.

Course Content

PN JUNCTION DEVICES : PN junction diode –structure, operation and V-I characteristics, diffusion and transition capacitance -Rectifiers – Half Wave and Full Wave Rectifier,– Display devices- LED, Laser diodes, Zener diode characteristics- Zener Reverse characteristics – Zener as regulator

TRANSISTORS AND THYRISTORS: BJT, JFET, MOSFET- structure, operation, characteristics and Biasing UJT, Thyristors and IGBT -Structure and characteristics.

AMPLIFIERS: BJT small signal model – Analysis of CE, CB, CC amplifiers- Gain and frequency response – MOSFET small signal model– Analysis of CS and Source follower – Gain and frequency response-High frequency analysis.

MULTISTAGE AMPLIFIERS AND DIFFERENTIAL AMPLIFIER: BIMOS cascade amplifier, Differential amplifier – Common mode and Difference mode analysis – FET input stages – Single tuned amplifiers – Gain and frequency response – Neutralization methods, power amplifiers –Types (Qualitative analysis).

FEEDBACK AMPLIFIERS AND OSCILLATORS: Advantages of negative feedback – voltage / current, series, Shunt feedback –positive feedback – Condition for oscillations, phase shift – Wien bridge, Hartley, Colpitts and Crystal oscillators.

Text Books:

1. David A. Bell ,"Electronic devices and circuits", Oxford University higher education, 5th edition 2008.
2. Millman J and Grabel A, "Microelectronics", Tata McGraw-Hill Publishing Company Ltd., New Delhi, Third Edition, 2000.
3. Boylestead L R and Nashelsky L, "Electronic Devices and Circuit theory", Pearson Education India, New Delhi, Ninth Edition, 2006.
4. Sedra and smith, "Microelectronic circuits",7th Ed., Oxford University Press.

Reference Books

1. Balbir Kumar, Shail.B.Jain, "Electronic devices and circuits" PHI learning private limited, 2nd edition 2014.
2. Thomas L.Floyd, "Electronic devices" Conventional current version, Pearson prentice hall, 10th Edition, 2017.
3. Donald A Neamen, "Electronic Circuit Analysis and Design" Tata McGraw Hill, 3rd Edition, 2003.
4. Robert L. Boylestad, "Electronic devices and circuit theory", 2002.
5. Robert B. Northrop, "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", CRC Press, 2004.

Course Outcomes

On completion of the course, students should be able to

1. Explain the structure and working operation of basic electronic devices.
2. Able to identify and differentiate both active and passive elements
3. Analyse the characteristics of different electronic devices such as diodes and transistors
4. Choose and adapt the required components to construct an amplifier circuit and acquire knowledge in designand analysis of oscillators

ICPE53 - DATA STRUCTURES AND ALGORITHMS

Course type: Programme Elective (PE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

- To introduce first level topics covering basics in Algorithms and Data Structures
- To provide examples for various design paradigms
- To identify the basic properties of graphs and trees and model simple applications

Course Content

Introduction to problem solving, Mathematical preliminaries, Growth of functions, time complexity and space complexity, worst-case and average-case analyses, use of order notations and related results, recurrence relations: substitution method, recurrence trees, Master's theorem and its applications.

Insertion-Sort, Divide and Conquer Strategy and Merge-Sort, Heap-sort, Quick-sort, Randomized versions ofQuick-sort, sorting in linear time,

Elementary data structures (Arrays, Stacks, Queues, Linked Lists), Hash tables, Binary search trees, Advanced data structures: B-Trees, Fibonacci heaps, Data structures for disjoint sets (for applications in control system design).

Dynamic Programming, Greedy Algorithms, B-Trees, Elementary Graph Algorithms, Arithmetic Circuits, Matrix Operations, Linear Programming, Polynomials and FFT, Number Theoretic Algorithms

Advanced Topics – NP-Completeness, Approximation Algorithms, Randomized Algorithms, Applications in Engineering – Control Systems, VLSI Design, etc.

Course Outcomes:

Students will be able to
1. Use linear and nonlinear data structures to solve real-time problems
2. Apply basic searching and sorting techniques in different application domains
3. Use design strategies to solve complex problems

Text Books:

1. Cormen TH, Leiserson CE, \and Rivest RL, Introduction to Algorithms, 3rd Edition, Prentice Hall ofIndia. (This book is popularly called as C-L-R)
2. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, ―Fundamentals of Computer Algorithms‖, Second Edition, Universities Press, 2008.
3. Kenneth A. Berman and Jerome L. Paul, Algorithms, Cengage Learning India, 2010.
4. Alfred V Aho, John E Hopcroft and Jeffrey D Ullman, ―The Design and Analysis of Computer Algorithms‖, First Edition, Pearson Education, 2006.
5. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, Introduction to Algorithms, 4th Edition, MIT Press, PHI, 2021

ICPE54 – NUCLEAR INSTRUMENTATION

Course Type:	Program Electives (PE)	***Pre-requisites:***	-
No. of Credits:	3		

Course Learning Objectives:

- To introduce the basic concept of radioactivity, properties of alpha, beta and gamma rays
- To study various radiation detectors, detector classification
- To study the electronics and counting systems
- To study applications of nuclear instrumentation in medicines, Industry and in Agriculture.

Course Content:

Radioactivity: General properties of Nucleus, Radioactivity, Nature of Nuclear Radiation's, Properties of Alpha, Beta and Gamma rays, Natural and artificial radio-activity. Radioactivity Laws, Half-life period, radioactive series, Isotopes and Isobars, Various effects- photoelectric, Compton scattering and pair production, stopping power and range of charged nuclear particles

Radiation Detectors: Techniques for radiation detection, Detectors for Alpha, beta and gamma rays, Detector classification, Gas filled detectors - volt ampere characteristics, Ionization chamber, Proportional counter, Geiger Muller counter, designing features, Scintillation detectors, Photomultiplier tube, dark currents, pulse resolving power, efficiency of detection, Solid state detectors (Lithium ion drifted – Si-Li, Ge-Li, Diffused junction, surface barrier detectors)

Electronics and Counting systems**:** Pre-amp, shaping amplifiers, Discriminators, Scalars and count rate meters, Pulse shaping, peak stretchers, photon counting system block diagram, single channel analyser SCA (pulse height analyser - PHA), Coincidence detection

Nuclear Spectroscopy systems: Factors influencing resolution of gamma energy spectrum, Energy resolution in radiation detectors, Multichannel analysers (MCA), Role of Nuclear ADC's – performance parameters.

Radiation Monitors andApplication in Medicines**:** Radiation uptake studies – block diagram and design features. Gamma camera – design, block diagram, medical usage. Nuclear instrumentation for health care, Radiation Personnel Health Monitors like neutron monitors, Gamma Monitors, Tritium monitors, Iodine monitors and PARA (particulate activity radiation alarms).

Applications in Industry**:** Basic Nuclear Instrumentation system – block diagram, Personal monitors like Thermo Luminescence Detectors (TLD). Dosimeters, Tele-detectors. Nuclear Instrumentation for power reactor. Nuclear Instrumentation for Toxic fluid tank level measurement, weighing, thickness gauges, Agriculture applications like food irradiation, Underground Piping Leak detection, water content measurement etc.

Text Books:

1. G.F. Knoll, Radiation Detection and Measurement, 2nd Edition, John Wiley and Sons,1998.
2. P.W. Nicholson, Nuclear Electronics, John Wiley, 1998.
3. S.S. Kapoor and V.S. Ramamurthy, Nuclear Radiation Detectors, Wiley Easter Limited,1986.

Reference Books:

1. Gaur and Gupta, Engineering Physics, Dhanpat Rai and Sons, 2001.
2. Irvin Kaplan, Nuclear Physics , Narosa, 1987.
3. M.N. Avdhamule and P.G. Kshirsagar, Engineering Physics, S. Chand and Co., 2001.
4. R.M. Singru, Introduction to Experimental Nuclear Physics, Wiley Eastern Pvt. Ltd., 1974.
5. B.R. Bairi, Balvinder Singh, N.C. Rathod, P.V. Narurkar , Hand Book of Nuclear Medical Instruments, TMH Publishing New Delhi, 1974.

Course Outcomes

1. The students get well versed with construction and working of various radiation detectors.
2. Students also get thorough knowledge of electronics and counting systems used in nuclear instrumentation
3. Students get detailed information about applications of nuclear instrumentation in medicine, industry etc.

ICPE55 - CONDITION MONITORING

Course Type: Program Electives (PE) ***Pre-requisites:***
No. of Credits: 3

Course Learning Objectives:

1. To introduce the importance of condition monitoring in the automotive, structural and process industries
2. To make understand the role of different sensors and signal conditioning techniques in the condition monitoring
3. To expose to wireless sensor networks and their protocols
4. To provide knowledge of machine learning and its relation with condition monitoring
5. To provide real time exposure in continuous condition monitoring.

Course Content:

Introduction: Motivation for condition monitoring, Historical overview – Reactive Maintenance, Scheduled Maintenance, Condition Based Preventive Maintenance, Predictive Maintenance and Digital Twin. Structural Health Monitoring (SHM) – Advantages and Challenges. Machinery Fault Diagnosis - Principles, Fault diagnostics and Prognostics. Environmental Monitoring – Air, Water, Soil contamination. Local and Global health monitoring.

Sensors and Signal Conditioning Techniques:Vibration Monitoring – Accelerometers, Types. Temperature Monitoring – Thermocouple, RTD (Resistance Temperature Detector), Infrared Thermography. Fiber Optic Sensors, NDT (Non-Destructive Testing) – Eddy Current Testing, Magnetic Particle Inspection (MPI), Dye Penetration, Acoustic Emission and its applications. Smart Sensing for condition monitoring. Data Acquisition Systems, Application of various signal processing methods – Time domain analysis, Frequency domain analysis, Non-stationary signal analysis.

Role of Wireless Sensor Networks in Condition Monitoring:Introduction to WSN – Network Topologies, Advantages and Challenges. IEEE 802.11 Standard. Wireless Network Protocols – Bluetooth, WiFi, Zigbee, 5G, NFC, RFID. RFID Technology - General Block diagram, Applications in Condition Monitoring. Introduction to Energy Harvesting Techniques. Comparison of Wired and Wireless Condition Monitoring.

Machine Learning (ML) for Condition Monitoring :Introduction, Review of Linear Algebra, Logistic Regression, Regularization, Neural Networks – Representation and Learning, Machine Learning System Design, Support Vector Machines, Unsupervised Learning, Dimensionality Reduction, Anomaly Detection. Application to Condition Monitoring.

Applications and Case Studies:Future of Condition based Monitoring – SHM and Rotating Machinery[2], Railway – Noise and Vibration Monitoring, Crack Detection in Composites (Aerospace structures), Condition Monitoring in – Agriculture, Biomedical, Food Processing and Packaging, Pipelines and Piping.
Case study 1 – Machine Fault Diagnosis using Vibration analysis (Wired sensing).
Case study 2 – Crack characterization of metallic structures using RFID Sensor (Wireless sensing).

Text Books:

1. Philip Wild, Industrial Sensors and Applications for Condition Monitoring, Professional Engineering Publishing, April 20, 1994.
2. Fu Ko Chang, Structural Health Monitoring: Current Status and Perspectives, Stanford University - 1997.
3. Amiya Ranjan Mohanty, Machinery Condition Monitoring Principles and Practices, CRC press, Taylor and Francis ,2017.
4. Andrew Ng, Machine Learning Yearning, 2018.

Course Outcomes:

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

1. Familiar with the need of condition monitoring in the automotive, structural and process industries.
2. Gain the knowledge of sensors and signal conditioning techniques used for effective condition monitoring.
3. Understand the operation of wireless sensor networks and their deployment.
4. Gain the knowledge of machine learning and its application in condition monitoring.
5. Develop/Design an application specific condition monitoring system for fault diagnosis and Prognosis.

ICPE56 – SAFETY INSTRUMENTED SYSTEM

Course type:	Programme Elective (PE)	***Pre-requisites:***	-
No. of Credits:	3		

Course Objectives

1. To make the students aware of basic concepts of safety instrumented system, standards and risk analysis techniques.
2. To make the students understand different layers of protection.
3. To make student conscious about safety instrumentation applications.
4. To make the students aware of potential events and impact of failures.
5. To make students aware of design, installation and maintenance procedures.

Course Content

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

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

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

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

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

Text books:

1. Paul Gruhn and Harry L. Cheddie, Safety Instrumented systems: Design, Analysis and Justification, ISA, 2nd edition, 2018.
2. Eric W. Scharpf, Heidi J. Hartmann, Harlod W. Thomas, Practical SIL target selection: Risk analysis per the IEC 61511 safety Lifecycle, exida2nd Edition 2016.

Reference books:

1. William M. Goble and Harry Cheddie, Safety Instrumented Systems Verification: Practical Probabilistic Calculations ISA, 2005.
2. Edward Marszal, Eric W. Scharpf, Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis, ISA, 2002.
3. Standard - ANSI/ISA-84.00.01-2004 Part 1 (IEC 61511-1 Mod) Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Software Requirements, ISA, 2004.

Course Outcomes:

On completion of the course, the students will develop

1. Ability to analyse the role of safety instrumented system in the industry.
2. Ability to Identify and analyse the hazards.
3. Ability to determine the safety integrity level for an application.
4. Ability to characterize the safety environment in industry.
5. Ability to analyse the failure modes, failure rates and MTBF using various reliability engineering tools.
6. Ability to apply the design, installation and maintenance procedures for SIS applied to industrial processes.
7. Ability to present the results in written and oral forms.

ICPE57 – CYBER SECURITY FOR INDUSTRIAL AUTOMATION

Course type: Programme Elective (PE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives

1. To understand the Industrial security environment and cyberattacks
2. To analyze and assess risks in the industrial environment
3. To access, design and implement cybersecurity
4. To test and troubleshoot the industrial network security system

Course Content:

INTRODUCTION: Industrial security environment-Industrial automation and control system (IACS) culture Vs IT
Paradigms-Cyberattacks: Threat sources and steps to successful cyberattacks

RISK ANALYSIS :Risk identification, classification and assessment, Addressing risk: Cybersecurity Management
System (CSMS), organizational security, physical and environmental security, network segmentation, access control, risk management and implementation.

ACCESSING THE CYBERSECURITY OF IACS:Identifying the scope of the IACS- generation of cybersecurity information-identification of vulnerabilities- risk assessment-evaluation of realistic threat scenarios- Gap assessment-capturing Ethernet traffic- documentation of assessment results

CYBERSECURITY DESIGN AND IMPLEMENTATION ;Cybersecurity lifecycle- conceptual design process- detailed design process- firewall design remote access design- intrusion detection design

TESTING AND MAINTENANCE; Developing test plans- cybersecurity factory acceptance testing- site acceptance testing- network and application diagnostics and troubleshooting- cybersecurity audit procedure- IACS incident
response

Text books:

1. Ronald L and Krutz,, Industrial Automation and Control System Security Principles, ISA, 2013.
2. David J. Teumim,, Network Security, Second edition, ISA,2010

Reference books:

1. Edward J.M. Colbert and Alexander Kott, Cyber-security of SCADA and other industrial control systems, Springer, 2016.
2. Perry S. Marshalland John S. Rinaldi, Industrial Ethernet, Second edition, ISA, 2004

Course Outcomes:

On completion of the course, the students will develop

1. Ability to apply basis of science and engineering to understand Industrial securityenvironment and cyberattacks.
2. Ability to analyze and assess risks in the industrial environment
3. Ability to access the cybersecurity of IACS
4. Ability to design and implement cyber security
5. Ability to test and troubleshoot the industrial network security system.
6. Ability to understand, investigate and explore feasible solution for a moderate industrial problem.

ADVANCED LEVEL (HO) COURSES FOR B. TECH. (HONOURS)

ICHO10 – DESIGN OF SENSORS AND TRANSDUCERS

Course Type: Honours (HO) ***Pre-requisites:*** ICPC13
No. of Credits: 4

Course Objectives:

1. To provide fundamentals of various types of diaphragm design.
2. To familiarize with design of strain gauge, capacitive and inductive based transducers and its applications.
3. To furnish the knowledge on design of accelerometer and gyroscope.
4. To provide the basics of various chemical sensors and its design criterion.

Course Content:

Introduction to diaphragm; Diaphragm performance and materials, Design of flat diaphragms, flat diaphragms with rigid centre convex diaphragms, rectangular diaphragms corrugated diaphragms and semiconductor diaphragms through analytical and numerical simulation.

Design of strain gauge-based load cells, torque sensors, force sensors and pressure sensors (Theory and experimentation)

Design of capacitance-based displacement, pressure and level sensors; Design of mutual inductance transducers for measurement of displacement and experimentation. Design of proximity sensors and practical demonstration.

Accelerometer and Gyroscopic design and its applications. Design of Hall Effect sensors, and practical demonstration of few applications.

Introduction to chemical Sensors, characteristics. Design of DO2 sensor, ChemFETs, PEMFCs.

Text Books:

1. Karl Hoffmann, An introduction to stress analysis and transducer design using strain gauges, HBM, 1989.
2. James W. Dally, William F. Riley, Kenneth G. McConnell, Instrumentation for Engineering Measurements, Wiley, 1993.
3. Di Giovanni, Flat and Corrugated Diaphragm Design Handbook, CRC Press, 1982.
4. Fraden, Jacob, Handbook of Modern Sensors: Physics, Designs, and Applications, Springer, 3rd Editions, 1993.

Reference Books:

1. Richard S. Figliola, Donald E. Beasley, Theory and Design for Mechanical Measurements, John Wiley and Sons, Inc, 6th Edition,1991.
2. Authors: Fraden, Jacob, Handbook of Modern Sensors: Physics, Designs, and Applications, Springe, 3rd Editions, 2010.
3. Alexander D. Khazan, Transducers and Their Elements: Design and Application, PTR Prentice Hall,1994
4. B.E. Noltingk, Instrumentation Reference Book, Butterworth- Heinemann, 2nd Edition 1995.
5. Peter H. Sydenham, Richard Thorn, Handbook of Measuring System Design, Wiley,2005
6. John G. Webster, Sensors and Signal Conditioning, Wiley Inter Science, 2nd Edition,2008
7. Patranabis, Sensors and Transducers, Prentice Hall, 2nd Edition,2003.
8. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd
9. Kirianaki N.V., Yurish S.Y., ShpakN.O., Deynega V.P., Data Acquisition and Signal Processing for Smart Sensors, John Wiley and Sons, Chichester, UK, 2002

Course Outcomes:

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

1. Select and design diaphragm for different practical applications.
2. Design strain gauge-based torque, force, load and pressure measurement systems.
3. Design capacitance/ inductance transducers for the measurement of displacement, pressure and level.
4. Acquire knowledge in design of accelerometer and gyroscope.

ICHO11 - INSTRUMENTATION SYSTEM DESIGN

Course Type: Honours (HO) ***Pre-requisites:*** ICPC20
No. of Credits: 4

Course Learning Objectives:

1. To impart the design knowledge of flow measurement and temperature measurement devices.
2. To introduce about control valve sizing and section of pumps for practical applications.
3. To introduce the process of Electronic product design
4. To familiarize with the Control Panel design and Control room design details.

Course Content:

Flow measurement: Design of Orifice meter, Rotameter, Electromagnetic flow meter, Ultrasonic flow meter, Coriolis flow meter. Temperature measurement: RTD measuring circuit, cold junction compensation circuit for thermocouple, linearization of thermistor characteristics and design of temperature transmitter.

Review of flow equations. Valve selection and sizing for liquid service, gas or vapor service, flashing liquids, mixed phase flow. Control valve noise. Control valve cavitations. Actuator sizing. Design of safety relief valves and rupture discs.

Valves: Control valves - design of actuators and positioners - types of valve bodies - valve characteristics- materials for body and trim - sizing of control valves - selection of body materials and characteristics of control valves for typical applications.

Electronic product design: System Engineering, ergonomics, phases involved in electronic product design. Enclosure Design: Packing and enclosures design guidelines, Grounding and shielding, front panel and cabinet design of an electronic product

Control Panel Design: Panel selection-size, type, construction and IP classification. GA Diagrams, Power wiring and distribution, Typical wiring diagrams for AI, DI, AO,DO, RTD, and T/C modules. Earthing scheme. Panel ventilation, cooling and illumination. Operating consoles- ergonomics. Wiring accessories- ferules, lugs, PVC ducts, spiral etc. Wire sizes and color coding. Packing, Pressurized panels- X, Y, and ZPurging for installation in hazardous areas. Ex-proof panels. Control Room Design: Layout and environment.

Text Books

1. Bela G. Liptak, Instrument Engineer’s Hand Book – Process Control, Chilton Company, 3rd Edition, 1995.
2. Andrew Williams, Applied instrumentation in the process industries, 2nd Edition, Vol. 1 and 3, Gulf publishing company (1993)

3. Anderson N.A., Instrumentation for Process Measurement and Control, Routledge, 3rd Edition, 1997.
4. Considine D.M., Process Instruments and Controls Handbook, McGraw-Hill., 5th Edition2009.
5. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd (2011)

Reference Books

1. R. W. Zape, Valve selection hand book third edition, Jaico publishing house,
2. Les Driskell, Control valve sizing, ISA.
3. Curtis Johnson, Process Control Instrumentation Technology, PHI /Pearson Education 2002.
4. Kim R Fowler, Electronic Instrument Design, Oxford University- 1996.
5. Manual on product design: IISc C.E.D.T.
6. Harshvardhan, Measurement Principles and Practices, Macmillan India Ltd-1993
7. Mourad Samiha and Zorian Yervant, Principles of Testing Electronic Systems, New York. John Wiley and Sons, 2000.
8. Anand M S, Electronic Instruments and Instrumentation Technology, New Delhi. Prentice Hall of India, 2004. 11. Ott H W, Noise Reduction Techniques in Electronic System., (2) John Wiley and Sons New York, 1988.
9. Johnson C.D., Process Control Instrumentation Technology, Prentice Hall of India, 8th Edition, 2009.
10. B.E. Noltingk, Instrumentation Reference Book, Butterworth- Heinemann, 2nd Edition 1995.

Course Outcomes:

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

1. Design temperature and flow measurement system for process application.
2. Design and Analyse CV Sizing
3. Identify various Control panels and Control Room details
4. Design an electronic product.

ICHO12 - MICRO SYSTEM DESIGN

Course Type: Honours (HO) ***Pre-requisites:*** ICPE13
No. of Credits: 4

Course Objectives:

1. To provide knowledge on MEMS design and various fabrication process.
2. To impart knowledge on mechanics of membranes and beams in micro scale.
3. To convey the design principles of electrostatic actuation and sensing.
4. To impart design knowledge on micro pressure sensor and micro accelerometer.
5. To provide knowledge on MEMS sensor integration and packaging.

Course Content:
Introduction, An approach to MEMS design, Basic introduction to fabrication, process integration.

Energy conserving transducer, Mechanics of membranes and beams

Electrostatic Actuation and Sensing, Effects of electrical excitation

Design of Micro pressure sensor and Micro accelerometer

Electronic Integration and Packaging

Text Books:

1. Peter D. Senturia, Microsystem Design, Kluwer Academic Publishers, Boston, 1^{st} Edition, 2001.

Reference Books:

1. Minhang Bao., Analysis and Design Principles of MEMS Devices, Elsevier, 1^{st} Edition, 2005.
2. M. Elwenspoek, R. Wiegerink, Mechanical Microsensors, Springer, Berlin, 1^{st} Edition, 2001.
3. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill, Boston, 2002.
4. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, and V. K. Aatre., Micro and Smart Systems by, Wiley-India, 2010

Course Outcomes:

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

1. Design and fabricate simple micro devices.
2. Design and analyse simple mechanical structures used in sensor actuator.
3. Design electrostatic based actuation and sensing devices, micro pressure sensor and micro accelerometer.
4. Understand sensor integration and packaging techniques.

ICHO13 – CONTROL SYSTEM DESIGN

Course Type: Honours (HO) ***Pre-requisites:*** ICPC16, ICPC19
No. of Credits: 4

Course Objectives:

1. To impart knowledge in the concepts and techniques of linear and nonlinear control system analysis and synthesis in the modern control (state space) framework.
2. To teach the control design using the classical design principles
3. To teach the controller and observer designs

Course Content

Design of Feedback Control Systems: Introduction; Approaches to System Design; Cascade Compensation Networks; Phase-Lead Design Using the Bode Diagram; Phase-Lead Design Using the Root Locus; System Design Using Integration Networks; Phase-Lag Design Using the Root Locus; Phase-Lag Design Using the Bode Diagram; Design on the Bode Diagram Using Analytical Methods; Systems with a Pre-filter; Design for Deadbeat Response; Design Examples.

Design of State Variable Feedback Systems Introduction, State space representation of physical systems, State space models of some common systems like R-L-C networks, DC motor, inverted pendulum etc., Controllable Canonical Form, Observable Canonical Form, Diagonal Canonical Form, State transition matrix, Solution of state equations, Controllability and Observability, Full-State Feedback Control Design; Observer Design; Integrated Full- State Feedback and Observer; Tracking Reference Inputs; Internal Model Design; Design Examples.

Lyapunov's stability and optimal control positive/negative definite, positive/negative semi-definite functions, Lyapunov stability criteria, introduction to optimal control, Riccatti Equation, Linear Quadratic Regulator, Design Examples.

Text Books:

1. Bernard Friedland, Control System Design: An Introduction to State-Space Methods (Dover Books on Electrical Engineering), Dover Publications Inc., 2005.
2. Gene F. Franklin, J. Da Powell, Abbas Emami-Naeini, Feedback Control of Dynamic Systems, Pearson Prentice Hall, 7^{th} Edition, 2014.
3. Richard C Dorf, Robert H Bishop, Modern Control Systems, Pearson Education India, 12^{th} Edition, 2013.
4. Albertos, P., and Mareels, I., Feedback Control for Everyone, Springer Verlag,2010. Available for free download.

5. Brogan, W.L., Modern Control Theory, Prentice Hall, 1993. Cheaper Indian Edition is available
6. Strogatz, S.H., Nonlinear Dynamics and Chaos: with Applications to Physics, Biology, Chemistry, and Engineering, 2^{nd} Edition, Westview Press (USA), Basic Books (India) 2014
7. Liu, Y-Y., and Barabási, A-L., Control Principles of Complex Systems, Reviews of Modern Physics, Vol. 88, pp. 1-58, 2016
8. Corke, P., Robotics, Vision and Control, 2^{nd} Edition, Springer International, 2017.

Reference Books:

1. Katsuhiko Ogata, Modern Control Engineering, Pearson, 5^{th} Edition, 2009.
2. Madan Gopal, Modern Control System Theory, New Age International Private Limited, 2014.

Course Outcomes:

On completing this course, the student would be able to,

1. Develop mathematical models for various physical systems.
2. Design state feedback controllers and observers.
3. Design nonlinear controllers using Lyapunov theory.
4. Analyse the stability of nonlinear system.

ICHO14 - ADVANCED PROCESS CONTROL

Course Type: Honours (HO) ***Pre-requisites:*** ICPC16, ICPC22
No. of Credits: 4

Course Objectives:

1. To expose students to the advanced control methods used in industries and research.
2. To teach various system identification and parameter estimation techniques.
3. To prepare the student to take up such challenges in his profession.

Course Content:

Review of System Identification, Parametric and non-parametric methods of system identification, Different family of BJ model; Choice of Input Signals; Least square (LS), Recursive LS, Weighted LS method of system identification.
Introduction to optimal filtering – need for filtering – Noise characteristics- Development of different state estimation techniques such as Kalman filter, Extended Kalman filter, Uncentered Kalman filter and particle Kalman filter. Development and validation of the state estimation/filtering concept with simulated non-linear systems using simulation software.
Development of SDCS system – Review of conventional Digital Control system – Development of SMPC, IMC and Performance enhancement of digital PID controller algorithm - Multivariable control strategies; Model Predictive Control, Model forms forModel Predictive Control. Dynamix matrix controller (DMC)
Development of augmented state space model – GPC – Controller Tuning and Robustness Issues; Extensions to Constrained and Multivariable Cases. Introduction to next generation controller – RTDA controller – Objective function – Derivation of control law – Implementation of above Digital control system using simulation software with case studies.
Case studies of APC estimation/filtering and controller concept with industrial process control applications.

Text Books:

1. B.W. Bequette, Process Control Modeling, Design and Simulation, Prentice Hall of India, New Delhi,2004.
2. D.E. Seborg, T.E. Edgar, D.A. Mellichamp. Process Dynamics and Control, Wiley India Pvt. Ltd., Fourth Edition.2016.
3. Ceil L. Smith., Advanced Process Control: Beyond Single Loop Control, 1st Edition,
   Wiley-AIChE (2010)

Reference Books

1. B.A. Ogunnaikeand, W.H. Ray, Process Dynamics, Modelling and Control, OxfordPress, 1994.
2. W.L. Luyben, Process Modelling Simulation and Control for Chemical Engineers, McGraw Hill, 2nd Edition, 1990.
3. S. Bhanot, Process Control: Principles and Applications, Oxford University Press, 2008.
4. Les Kane., Advanced Process Control and Information Systems for the Process Industries, Gulf Professional Publishing. (1999)

Course Outcomes:

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

1. Design an appropriate advanced controller for specific problems in process industries.
2. Develop suitable filters for linear/non-linear system
2. Design of SDCS for multivariable systems.
3. Develop the MPC and next generation controller for multivariate system

ICHO15 – OPTIMAL AND ROBUST CONTROL

Course Type: Honours (HO)
No. of Credits: 4
Pre-requisites: ICPC16, ICPC19

Course Objectives:

1. Introduce analysis and design techniques for multivariable control systems to undergraduate students

Course Content:

Introduction, Linear Algebra, Linear Dynamical Systems (Review of state-space theory)

Performance Specifications, Stability and Performance of Feedback Systems.

Model Uncertainty and Robustness – Structured Singular Values, Parameterization of Stabilizing Controllers, Algebraic Riccati Equations.

H-infinity optimal control, linear quadratic optimization, H-infinity loop shaping, Controller order reduction, Fixed order controllers.

Discrete-time Control – Discrete Lyapunov equations, Discrete Riccati equations, Bounded Real Functions, Discrete-time H_2 control, Controller order reduction using co-prime factorization.

Text Books:

1. D.E. Kirk, Optimal Control Theory: An Introduction, Dover Publications, 2004
2. J. C. Doyle, B. Francis and A. Tannenbaum, Feedback Control Theory, Macmillan, 1990.
3. A. E. Bryson Jr. and Y. C. Ho, Applied Optimal Control, Taylor and Francis, 1975.
4. P J Nahin, When Least is Best, Princeton Univ. Press, 2004,
5. D Bertsimas and J N Tsitsiklis, Introduction to Linear Optimization, Athena Scientific,1997.
6. H A Taha, Operations Research: An Introduction, 9/e, Pearson Education, 2014.
7. D Bauso, Game Theory with Engineering Applications, SIAM, 2016.
8. K Morris, Introduction to Feedback Control, Academic Press, 2001.
9. H P Geering, Optimal Control with Engineering Applications, Springer Verlag, 2007.

Reference Books:

1. K. Zhou, J. C. Doyle and K. Glover, Robust and Optimal Control, Prentice-Hall, NJ07458, 1996.
2. A. A. Stoorvogel, H-infinity Control Problem: A State-space Approach, Prentice Hall, 1992

Course Outcomes:

Upon completing this course, the students would be able to,

1. Apply Optimization tools to multivariable feedback systems.
2. Use computer software to design MIMO robust controllers.
3. Perform a full design cycle on MIMO models of systems.

ICHO16 – SENSORS SYSTEMS DESIGN

Course Type: Honours (HO) ***Pre-requisites:*** ICPC 17
No. of Credits: 4

Course Learning Objectives:

1. To provide knowledge on the design of signal conditioning circuits for resistive,capacitive and thermal transducers to improve the sensor characteristics.
2. To provide knowledge on the design of transmitters with industrial standard.
3. To impart the knowledge of data acquisition system design, sensor networks andbuses
4. To provide knowledge about the smart sensor design, direct sensor microcontrollerinterface and universal interfacing circuit.

Course Content:

Design of signal conditioning circuits for resistive, capacitive, thermal transducers for improving linearity, sensitivity and other required specifications and performance through hardware and software methods through theory and practical approach. Linearization, A/D conversion, temperature compensation. Noise analysis of interface circuits. Current, frequency, period or pulse-width modulation conversion

Review of transmitters – design of two wire and four wire transmitters using analogelectronic circuits and IC's. EMI and EMC design consideration for sensor interfacing circuit design.

Introduction to data acquisition system, issues related to interfacing of static and dynamic sensors. Design of data acquisition for a given measurement application through theory and practical approach. Introduction to Sensor buses and sensor network protocols.

Smart sensors and digital sensor system design: Technologies and design methodology, IEEE 1451 standard and frequency sensors.

Direct sensor-microcontroller interface for resistive and capacitive transducers: design and practical implementation. Universal frequency to digital converter, universal sensors and transducer interface-features and performance, future trends in sensor circuit design.

Text Books:

1. Ramon Pallas Areny, John G. Webster, Sensors and Signal Conditioning, 2ndEdition, John Wiley and Sons, 2000.
2. Kirianaki N.V., Yurish S.Y., ShpakN.O., Deynega V.P., Data Acquisition andSignal Processing for Smart Sensors, John Wiley and Sons, Chichester, UK, 2002
3. Ferran Reverter, Ramon PallasAreny, Direct Sensor-to MicrocontrollerInterface Circuits: Design and Characterization, Marcombo S.A., 2005
4. Smart Sensors and MEMS, ed. by S.Y. Yurish and M.T. Gomes, Springer Verlag, 2005
5. A. Custodio, R. Bragos, R. Pallas-Areny, A Novel Sensor-Bridge-to- Microcontroller Interface, in Proceedings of IEEE Instrumentation and Measurement Technology Conference, Budapest, Hungary, 21-23 May, 2001.

Reference Books

1. Thomas L. Floyd, David Buchla, Fundamentals of analog circuits, 2002-Prentice Hall.
2. Ernest O. Doebelin; Measurement System Application and Design; Mc-Graw Hill; 5thEdition, 2003.
3. S. Y. Yurish, F. Reverter, R. Pallas-Areny, Measurement error analysis and uncertainty reduction for period-and time interval-to-digital converters based on microcontrollers, Measurement Science and Technology, Vol.16, No.8, 2005, pp.1660-1666.
4. William C. Dunn, Introduction to Instrumentation, Sensors, and ProcessControl, Artech House, 2005.
5. Jacob Fraden, Handbook of Modern Sensors: Physics, Designs, andApplications, Springer, 1993.
6. H.R. Taylor, Data Acquisition for Sensor Systems, Springer, 2010.
7. Manabendra Bhuyan, Intelligent Instrumentation: Principles and Applications,CRC Press Taylor and Francis Group, 2010.
8. B.E. Noltingk, Instrumentation Reference Book, Butterworth- Heinemann, 2ndEdition 1995.

Course Outcomes

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

1. Design signal conditioning circuits for resistive, capacitive and thermaltransducers
2. Design transmitters for the required physical parameters using analog circuitsand IC.
3. Interface sensors signal with DAQ, Microcontroller and will be familiar withsensor buses and protocols.
4. Design smart sensors systems with standard interfacing circuits.

OPEN ELECTIVE (OE) COURSES

ICOE10- BIOMEDICAL INSTRUMENTATION

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives

The course introduces the human physiological system with respect to medical instrumentation and its design and the instrumentation for measuring and analyzing the physiological parameters.

1. To educate the students on the different medical instruments.
2. To familiarize the students with the analysis and design of instruments to measure bio-signals like ECG, EEG, EMG, etc.
3. To have a basic knowledge in therapeutic devices
4. To introduce about the clinical laboratory instruments and familiar about electrical safety.

Course Content

Electro physiology**:** Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, electrode theory, bipolar and uni-polar electrodes, surface electrodes, needle electrode and microelectrode, physiological transducers-selection criteria and its application.

Bioelectric potential and cardiovascular measurement**s**: ECG recording system, Heart sound measurement-stethoscope, phonocardiograph (PCG), Foetalmonitor-ECG-phonocardiography, vector cardiograph, cardiac arrhythmia's monitoring system. EMG, EEG - Evoked potential response, ERG and EOG recording system. Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and direct measurement techniques.

Clinical Laboratory Equipment**:** Chemical tests in clinical laboratory, Automated Biochemical Analysis System. Blood gas analyzer, Acid –base balance, Blood PH measurement, blood PCO_2, blood PO_2, Intra –arterial blood gas analyzers, Blood cell counters- types of blood cells, - methods of cell counting -coulter counter- Automatic recognition and differential blood cell counting.

Respiratory and pulmonary measurements: Physiology of respiratory system, respiratory rate measurement- artificial respirator- oximeter, pulmonary function measurements–spirometer–photo plethysmography and body plethysmography. Principal and techniques of impedance pneumography, Apnea monitor.

Electrical safety: Sources of electrical hazards in medical environment and safety techniques for checking safety parameters of biomedical equipment.

Text Books

1. John G. Webster, John W Clark, jr, MedicalInstrumentationApplicationandDesign,4th Edition, JohnWiley and sons, New York, 2010
2. Arthur Guyton, John E. Hall, Text Book of Medical Physiology, 12th Edition, Elsevier Saunders, 2011.
3. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall of India, New Delhi,2014.
4. Jerry. L.Prince, Jonathan M. Links, Medical Imaging Signals and Systems, 2ndEdition, Pearson Prentice Hall, 2015.

5. Shakti Chatterjee and Aubert Miller, Biomedical Instrumentation Systems, CENGAGE Learning publishing, 2016.

Reference Books

1. Onkar N. Pandey, Rakesh Kumar, Bio Medical Electronics and Instrumentation, Katson
2. Books, 2011
3. Joseph J .Carr and John M.Brown, Introduction to Biomedical Equipment Technology, 4th Edition, Pearson publishing, 2013.
4. R.S. Khandpur, Hand Book of Biomedical Instrumentation, 3rd edition, McGraw Hill Education (India) Private Limited,2014.
5. M Arumugam, Biomedical Instrumentation Anuradha Publications,2015
6. Andrew G. Webb, Principles of Biomedical Instrumentation, Cambridge University Press, 2018;
7. Cromwell ,Biomedical Instrumentation and Measurement, 2nd Edition, Pearson India 2015

Course Outcomes

On completion of this course the students will be,

1. To understand, design and evaluate systems and devices that can measure, test and/or acquire bio-signal information from the human body.
2. Familiar with patient monitoring equipment used in hospitals.
3. Ability to explain the medical diagnostic and therapeutic techniques
4. Familiar with various clinical laboratory instruments used for diagnosis.

ICOE11– BIOMEDICAL SIGNAL PROCESSING

Course type: Open Elective (OE) ***Pre-requisites*:** -
No. of Credits: 3

Course Objectives

1. To expose the students to the importance of biomedical signals and analysis
2. To introduce different types of bio signals and their characteristics
3. To study different noise removal mechanisms for biomedical signals
4. To analyze the signals using time and frequency domain measures

Course Content

Introduction to signals, Continuous time and discrete time signals and LTI systems, Introduction and properties of Fourier transform, Laplace transform and Z-transform

Nature of biomedical signals; origin and dynamics of electroneurogram (ENG), electromyogram (EMG), electrocardiogram (ECG), electroencephalogram (EEG), event related potentials (ERP), electrogastrogram (EGG), phonocardiogram (PCG), vibromyogram (VMG) and vibroarthogram (VAG), Objectives of biomedical signal analysis and difficulties in biomedical signal analysis

Random, structured and physiological noise, noises and artefacts in ECG, EMG and EEG signals, Filtering for removal of artefacts; Introduction to filter design; Time domain filters, Frequency domain filters, and optimal filters and selection of appropriate filters

Event detections in ECG, EEG and heart sounds, Analysis of wave shape and waveform complexity, QRS complex, analysis of ERPs and analysis of electrical activity using time and frequency domain measures

Analysis of nonstationary and multicomponent signals, heart sound and murmurs, EEG rhythms and waves and case studies

Text Books

1. Rangayyan, R. M. (2015). Biomedical signal analysis (2nd Edition). Wiley-IEEE Press.
   ISBN: 0470911396 (Online ISBN 1119068129).
2. Eugene N. Bruce, Biomedical Signal Processing and Signal Modeling, AWiley-Interscience Publication JOHN WILEY and SONS, INC. ISBN0-471-34540-7. (2000)
3. B.P. Lathi, Principles of Linear Systems and Signals, Oxford University Press, 2ndEdition, 2009

Reference Books

1. Le Cerutti, S., and Marchesi, C. (Eds.). (2011). Advanced methods of biomedical signalprocessing (Vol. 27). John Wiley andSons.
2. Webster, J. G. (2009). Medical instrumentation application and design. John Wiley andSons.
3. Mitra, S.K., Digital Signal Processing: A Computer-Based Approach, McGraw Hill, NY, 4th Edition, 2011

Course Outcomes

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

1. understand the issues associated with the interpretation of biomedical signals
2. familiar with different signals such as ECG, EMG and EEG
3. able to remove the noises in bio signals by selecting appropriate filters
4. implement appropriate signal processing methods to extract reliable information

ICOE12 - MICRO ELECTRO MECHANICAL SYSTEMS

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives

1. To introduce the fundamental concepts of MEMS and Micro systems and their relevance tocurrent scientific needs.
2. To introduce the state-of-art micromachining techniques including surface micromachining,bulk micromachining, and related methods.
3. To make the students knowledgeable in the design concepts of micro sensors and microactuators.
4. To introduce the challenges and limitations in the design of MEMS devices
5. To make the students knowledgeable in computer aided design tools for modeling MEMSdevice.

Course Content

Introduction, emergence, MEMS application, scaling issues, materials for MEMS, Thin film deposition,lithography and etching.

Bulk micro machining, surface micro machining and LIGA process.

MEMS devices, Engineering Mechanics for Micro System Design – static bending of thin plates, Mechanical vibrational analysis, Thermomechanical analysis, fracture mechanics analysis, Thin film mechanics.

Theory and design: Micro Pressure Sensor, micro accelerometer – capacitive and piezoresistive, micro actuator.

Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

Text Books

1. Tai Ran Hsu, MEMS and Microsystem Design and Manufacture, TataMcGrawHill, New Delhi2002.
2. Marc Madou, Fundamentals of Micro fabrication, CRC Press, 2nd Edition, 2002.
3. Julian W. Gardner and Vijay K. Varadan, Microsensors, MEMS, and Smart Devices, JohnWiley and Sons Ltd, 1st Edition, reprinted2007.

Reference Books

1. Elwenspoek, Miko, Wiegerink, R, Mechanical Microsensors, Springer-Verlag Berlin Heidelberg GmbH, 1st Edition,2001.
2. Simon M. Sze, Semiconductor Sensors, John Wiley and Sons. Inc, 1st Edition,2008.
3. Chang Liu, Foundations of MEMS, Pearson Educational limited, 2nd Edition,2011.
4. Stephen D. Senturia., Microsystem Design, Kluwer Academic Publishers, 2001.
5. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, and V. K. Aatre., Micro and SmartSystems, Wiley-India, 2010.

Course Outcomes:

On completion of this course the students will be,

1. Able to understand the fundamental principles behind the working of micro devices/ systemsand their applications.
2. Able to knowledgeable in the standard micro fabrication techniques.
3. Able to identify micro sensors and actuators for a specific application.
4. Able to do acquire skills in computer aided design tools for modeling and simulating MEMSdevices.

ICOE13 - MEASUREMENT AND CONTROL

Course Type: Open Elective (OE) ***Pre-requisites:***
No. of Credits: 3

Course Objectives

1. To impart knowledge in the basics of measurement system.
2. To expose the students to various measurement techniques used for the measurement of important process variables.
3. To expose the students to the basics of control systems.

Course Content

Fundamental and Importance of Instrumentation, types of instruments, selection of instruments, performance of instruments, error in measurement, calibration and standard, Calibration of instruments: Methods and analysis, Introduction to Transducer and types, Process Instrumentation, recording instruments, indicating and recording Instruments.

Strain and Displacement Measurement:
Factors affecting strain measurements, Types of strain gauges, theory of operation, strain gauge materials, gauging techniques and other factors, strain gauge circuits and applications of strain gauges. Resistive potentiometer (Linear, circular and helical), L.V.D.T., R.V.D.T. and their characteristics, variable inductance and capacitance transducers, Piezo electrical transducers, Hall Effect devices and Proximity sensors.

Pressure and Temperature Measurement:
Mechanical devices like Diaphragm, Bellows, and Bourdon tube for pressure measurement, Variable inductance and capacitance transducers, Piezo electric transducers, L.V.D.T. for measurement of pressure.
Resistance type temperature sensors – RTD and Thermistor, Thermocouples and Thermopiles, Laws of thermocouple, Fabrication of industrial thermocouples, Radiation methods of temperature measurement.

Flow and Level Measurement:
Differential pressure meters like Orifice plate, Venturi tube, flow nozzle, Pitot tube, Rotameter, Turbine flow meter, Electromagnetic flow meter, Ultrasonic flowmeter.
Resistive, inductive and capacitive techniques for level measurement, Ultrasonic methods, Air purge system (Bubbler method).

Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems, brief idea of multivariable control systems. Brief idea of proportional, derivative and integral controllers.

Text Books

1. D Patranabis, Principles of Industrial Instrumentation, Mc Graw hill, 3rdedition. 2007
2. A. K. Ghosh, Introduction to Instrumentation and Control, PHI publications, 4thedition. 2012
3. Nakra Chaudhari, Instrumentation measurement and analysis, Mc Graw hill, 3rdedition.2006
4. S. K. Bhattacharya, Control Systems Theory and Applications,Pearson.2013
5. N. C. Jagan, Control Systems, BSPublications.2015

6. S. K. Singh, Industrial Instrumentation andControl, TMH Publication.2009.

Reference Books

1. Thomos G. Beckwith and Lewis Back N. Adison Wesely Longman, Mechanical Measurements, Harlow.1993
2. E. D. Doeblin, Measurement Systems: Application and Design, McGraw – Hill Publication 1990.
3. I. J. Nagrath and M. Gopal, Control Systems Engineering, New Age International (P)Limited, Publishers.2018
4. N. K. Sinha, Control Systems, New Age International (P) LimitedPublishers.2013.

Course Outcomes

On completion of this course the students will be,

1. Familiar with the basics of measurement system, its characteristics and principles of few transducers.
2. Familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
3. Able to select and make measurements of temperature, flow, pressure and level in any process industry.
4. Familiar with the concept of closed loop control system.

ICOE14- INDUSTRIAL MEASUREMENTS

Course Type: Open Elective (OE) ***Pre-requisites:***
No. of Credits: 3

Course Objectives

1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement oftemperature, flow, pressure and level in process industries.
3. To make the students knowledgeable in the design, installation and troubleshooting of processinstruments.

Course Content:

Temperature measurement: Introduction to temperature measurements, Thermocouple, Resistance Temperature Detector, Thermistor and its measuring circuits, Radiation pyrometers and thermal imaging.

Pressure measurement: Introduction, definition and units, Mechanical, Electro-mechanical pressuremeasuring instruments. Low pressure measurement, Transmitter definition types, I/P and P/I Converters.

Level measurement: Introduction, Mechanical and electrical methods of level measurement.

Flow measurement: Introduction, definition and units, classification of flow meters, differential pressure andvariable area flow meters, Positive displacement flow meters, Electro Magnetic flow meters, Hot wire anemometer and ultrasonic flow meters. Calibration and selection of Flow meters

Text Books

1. Ernest.O. Doebelin and Dhanesh.N. Manik, Doebelin’s Measurement Systems, McGraw HillEducation, 6th Edition, 2011.
2. B.G. Liptak, Process Measurement and Analysis, CRC Press, 4th Edition, 2003.
3. Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill, 3rd Edition, 2010.

Reference Books

1. B.E. Noltingk, Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition,1995.
2. Douglas M. Considine, Process / Industrial Instruments and Controls Handbook, McGraw Hill,Singapore, 5th Edition, 1999.
3. Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I andVol II, GulfPublishing Company, Houston,2001
4. Spitzer D. W., Industrial Flow measurement, ISA press, 3rd Edition, 2005.
5. Tony.R. Kuphaldt, Lessons in Industrial Instrumentation, Version 2.02, April2014

Course outcomes

On completion of this course, the students will be,

1. Familiar with the different temperature, pressure, flow and level measurement techniquesused in process industries.
2. Able to select and make measurements of temperature, flow, pressure and level in any processindustry.
3. Able to identify or choose temperature, flow, pressure and level measuring device for specificprocess.

ICOE15 - VIRTUAL INSTRUMENT DESIGN

Course Type: Open Elective (OE) ***Pre-requisites:***
No. of Credits: 3

Course Objectives

1. To introduce to the students about the interfacing techniques of various transducers.
2. To expose the students to different signal conditioning circuits.
3. To impart knowledge on the hardware required to build Virtual Instrument.
4. To impart knowledge to build GUI for Virtual Instrument.

Course Content

Transducer Interfacing: Interfacing techniques for the following transducers: Potentiometers - Temperature sensors – Thermocouple, RTD, Thermistors – Load cells – High and low range tension, Low and mid-range precision – Torque Sensors –Pressure sensors – Vibration Sensors – Acoustic Sensors – Automotive Sensors – Displacement sensors – Biomedical transducers.

Signal Conditioning: Filtering, Cold Junction Compensation, Amplification, Instrumentation Amplifier Linearization–CircuitProtection-Groundloops, CMRR, Noise Reduction and Isolation, Attenuation Multiplexing–Digitalsignalconditioning–IEEE1451standards–TransducerElectronicDataSheet (TEDS)

Data Acquisition and Hardware Selection: Overview of DAQ architecture – Analog IO and Digital IO - Finite and continuous buffered acquisition – Data acquisition with C language - Industrial Communication buses – Wireless network standards - Micro-controller selection parameters for a virtual instrument – CPU, code space (ROM), data space (RAM) requirements.

Real-Time OS for Small Devices: Small device real-time concepts – Resources - Sequential programming - Multitasking - RTOS – Kernels – Timing loops – Synchronization and scheduling – Fixed point analysis – Building embedded real-time application for small devices.

Graphical User Interface for Virtual Instrument: Building an embedded Virtual Instrument GUI – Text and Number display – GUI Windows management. – Simulation – Display drivers – Creating and distributing applications – Examples of Virtual Instrument design using GUI in any of the applications like consumer goods, robotics, machine vision, and process control automation.

Text Books

1. Daniel H. Sheingold, Transducer Interfacing Handbook – A Guide to Analog Signal Conditioning, Analog Devices Inc.1980.
2. Kevin James, PC Interfacing and Data Acquisition - Techniques for Measurement, Instrumentation and Control, Newnes, 2000.
3. Timothy Wilmshurst, Designing Embedded Systems with PIC Microcontrollers-Principles and Applications, Elsevier, 2007.

Reference Books

1. Jean Labrosse, Embedded System Building Blocks, 2nd Edition. RandD Books, 2000
2. Jean Labrosse, MicroC/OS-II – The Real-Time Kernel, 2nd Edition. CMP Books, 2002

Course Outcomes

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

1. Interface the target transducer to the signal conditioning board.
2. Condition the acquired signal from the transducer to standard data formats.
3. Select the most appropriate hardware for the virtual instrument to be built.
4. Implement the real-time OS for the selected micro-controller and the GUI interface for the virtual instrument.

ICOE16 - NEURAL NETWORKS AND FUZZY LOGIC

Course type: Open Elective (OE) ***Pre-requisites***: -
No. of Credits: 3

Course Objectives

1. To provide an overview of intelligent techniques.
2. Develop skills to gain a basic understanding of neural network and fuzzy logic theory.
3. To introduce different architectures and algorithms of Neural Networks.
4. To impart knowledge on Fuzzy set theory and Fuzzy rules.

Course Content

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent technique for real world Engineering applications.

Supervised and Unsupervised Neural networks: Perceptron, Standard backpropagation Neural network: Architecture, Algorithm and other issues. Discrete Hopfield's networks, Kohnen's self-organizing maps, adaptive resonance theory (ART1).

Neural networks for control systems: Schemes of Neuro-control, identification and control of dynamical systems, case studies.

Fuzzy set and operations, Fuzzy relations, Fuzzifications, Fuzzy rule-based systems, defuzzification fuzzy learning algorithms.

Fuzzy logic for control system with case studies. Introduction to neuro-fuzzy system and genetic algorithm.

Text Books

1. Timothy J. Ross, Fuzzy Logic with Engineering Applications, John Wiley and SonsLtd Publications, 4th edition,2016.
2. Laurene Fausett, Fundamentals of Neural networks, Pearson education, Eight Impression, 2012.

Reference Books

1. S. Haykin, Neural Networks: A comprehensive Foundation, Prentice Hall Inc., New Jersey, 2nd Edition, 1999.
2. Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, Prentice Hall, New Delhi, 1994.
3. Zdenko Kovacic, Stjepan Bogdan, Fuzzy Controller Design Theory and Applications, CRC Press, 1st edition, 2006.
4. Satish Kumar, Neural Networks–A classroom approach, Tata McGraw-Hill Publishing Company Limited, 2013.

Course Outcomes

On completion of this course, the students will be,

1. Familiar with the basic concepts of Neural Network and Fuzzy logic.
2. AbletodevelopNeuralNetworkbasedmodellingandcontrolfordifferentprocessapplications.
3. Able to design Fuzzy logic-based control system for process applications.
4. Able to design hybrid neuro-fuzzy architecture for engineering optimization problems.

ICOE17– NETWORK CONTROL SYSTEMS

Course type: Open Elective (OE) ***Pre-requisites*:** -
No. of Credits: 4

Course Objectives

5. To expose the students to the emerging field of multi-agent and network control systems
6. To expand the scope of traditional control systems to include large-scale interconnected systems
7. To demonstrate consensus and leader-follower paradigms in a distributed environment
8. To introduce different applications that fall in the gamut of network control systems.

Course Content

Introduction to multi-agent systems, Information exchange via local interactions, Basics of graph theory

Reaching agreement in undirected and directed networks, Agreement via Lyapunov functions, Agreement over random networks

Formation control, Shape based control, Dynamic formation selection, Assigning roles, Cooperative robotics, Wireless sensor networks

Graph theoretic controllability, Network formation, Optimizing the weighted agreement, Planning over proximity graphs, Higher order networks

Introduction to social networks, opinion dynamics, epidemics, games etc.

Text Books

3. Mehran Mesbahi and Magnus Egerstedt, Graph Theoretic Methods in Multiagent Networks, Princeton University Press, 2010.
4. F. Bullo, J. Cortes, and S. Martinez, Princeton, Distributed Control of Robotic Networks, University Press, 2009.

Reference Books

3. P. J. Antsaklis and P. Tabuada, Networked Embedded Sensing and Control, Springer, 2006.
4. A.L. Barabasi, Network Science, Cambridge University Press,2016

Course Outcomes

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

5. Design control system in the presence of quantization, network delay or packet loss.
6. Understand distributed estimation and control suited for network control system.
7. Develop simple application suited for network control systems.
8. Technically understand larger-scale techno-socio-economic networks and models prevalent in today’s society.

ICOE18 - CONTROL SYSTEMS

Course type: Open Elective (OE) **Pre-requisites:** -
No. of Credits: 4

Course Objectives

1. To introduce the concept of feedback control system.
2. To impart knowledge in mathematical modeling of physical systems.
3. To impart knowledge in characteristics and performance of feedback control system.
4. To teach a variety of classical methods and techniques for analysis and design of control systems.

Course Content

Review of Systems, Mathematical Models – Differential Equations, Linear Approximations and Transfer Functions, Block Diagrams and Signal Flow Graphs
Feedback Control System Characteristics, and Performance Specifications on transients and steady-state, Stability of Linear Feedback Systems – Routh-Hurwitz criterion.

The Root Locus Method, Feedback Control System Analysis and Performance Specifications inTime- Domain, Design of Lead, Lag, and PID Controller using Root Locus.

Frequency Response Methods, Nyquist's Stability Criterion, Bode Plots, Performance Specifications in Frequency-Domain, Stability Margins.
Design of Lead, Lag and PID controller in Frequency Domain.

Text Books

1. Dorf, R.C., Bishop, R.H., Modern Control Systems, Prentice Hall, 13th edition,2016.
2. Katsuhiko Ogata, Modern Control Engineering, PHI LearningPrivateLtd, 5thEdition, 2010.
3. Franklin, G.F., David Powell, J., Emami-Naeini, A., Feedback Control of Dynamic Systems, Prentice Hall, 7th Edition, 2014.

Reference Books

1. Nise, N.S., Control Systems Engineering, Wiley, 7th Edition, 2015.
2. John J.D., Azzo Constantine, H. and Houpis Stuart, N Sheldon, "Linear Control System Analysis and Design with MATLAB", CRC Taylorand Francis Reprint2009.
3. Dutton, K., Thompson, S., Barralough, B., The Art of Control Engineering, PrenticeHall, 1997.
4. M. Gopal., Control Systems: Principles and Design, 4th Edition, 2012, Mc Graw Hill Publication
5. Anish Deb, Srimanti Roychoudhury, Control System Analysis and Identification with MATLAB, Block Pulse and Related Orthogonal Functions, 1st Edition,CRC Press, 2018.

Course outcomes

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

1. Generate mathematical models of dynamic control system by applying differential equations.
2. Analyze and characterize the behavior of a control system in terms of different system, performance parameters and assess system stability.
3. Evaluate and analyses system performance using frequency and transient response analysis.
4. Design and simulate control systems (linear feedback control systems, PID controller, and multivariable control systems), using control software, to achieve required stability, performance and robustness.

ICOE19 - ENERGY HARVESTING TECHNIQUES

Course Type: Open Elective (OE) *Pre-requisites:* -
No of credit: 3

Course Objectives

1. To introduce basic energy harvesting techniques using smart materials and structures and combining with mechanisms.
2. To impart knowledge in the design of power converter circuits for ambient energy harvesters.
3. To introduce mathematical modelling of piezoelectric based energy harvesters.
4. To introduce on certain case studies.

Course Content

Energy Harvesting Basics, Analysis of ambient energy- Vibration, shock, wind, Thermal, RF, energy transducers- electromagnet, photovoltaic, piezoelectric and other smart materials- working principle, equivalent circuit models.

Vibrational energy harvesting- Electromechanical Modelling of Cantilevered Piezoelectric Energy Harvester for Persistent Base Motion-lumped parameter model, correction factors, coupled distributed parameter model, modelling assumptions, closed form solution for unimorph and bimorph configuration, harvesting techniques for broadband excitation

Piezoelectric energy harvesting circuits-low power rectifier circuits with resistive, linear and nonlinear reactive input impedance, piezoelectric pre-biasing, self-tuning, DC-DC switch mode converters, impedance matching circuits for maximum output power.

Electromagnetic energy harvesting- Wire wound coil properties, micro fabricated coils, magnetic materials, scaling of electromagnetic vibration generators and damping, maximizing power from an EM generator, micro and macro scale implementation.

Thermoelectric Energy harvesting- Harvesting Heat, thermoelectric theory, thermoelectric generators and its efficiency, matched thermal resistance, heat flux, design consideration, optimization for maximum output, matching thermoelectric to heat exchangers- thin film devices.

Case study- harvester driven by muscle power, knee joint movement harvesting, etc. strategies to improve energy conversion efficiency for different ambient sources.

Text Books

1. Shashank Priya and Daniel J. Inman, Energy Harvesting Technologies, Springer-Verlag New York, Inc., 1st Edition,2010.
2. DanickBriand, EricYeatman, and Shad Roundy, Micro energy Harvesting, Wiley-VCHVerlag GmbH and Co,2015.

Reference Books

1. Stephen Beeby, Neil white, Energy Harvesting for Autonomous Systems, Artechhouse, Norwwood,1st Edition ,2010.
2. Alper Erturk and Daniel J Inman, Piezoelectric Energy Harvesting, John Wiley and Sons.Ltd.1st Edition ,2011.
3. Tom J.Kazmiershi, Steve Beeby, Energy Harvesting System, Principles, Modelling and Application, springer, Newyork,2011.

Course Outcomes

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

1. Comprehend in the concept of various ambient energy harvesting techniques.
2. Design optimal power converting circuits for different harvesters.
3. Design vibration energy harvester for narrow and wide band excitation.
4. Design electromagnetic and thermoelectric based energy harvesters.
5. Apply the energy harvesting concepts to common engineering problems

ICOE20 – SMART MATERIALS AND SYSTEMS

Course type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives

1. To expose to the basics of sensors used in industries.
2. To provide adequate knowledge on smart instrumentation and wireless sensor networks.
3. To impart knowledge on various standard protocols used in wireless instrumentation.
4. To apply the knowledge of sensors, transceivers, controllers and power supplies to implement a WSN for a required application.

Course Content

Sensor Classification-Thermal sensors -Humidity sensors -Capacitive Sensors-Planar Inter digital Sensors-Planar Electromagnetic Sensors-Light Sensing Technology-Moisture Sensing Technology-Carbon Dioxide (CO_2) sensing technology-Sensors Parameters

Frequency of Wireless communication -Development of Wireless Sensor Network based Project-Wireless sensor based on microcontroller and communication device-Zigbee Communication device.

Power sources- Energy Harvesting –Solar and Lead acid batteries-RF Energy /Harvesting-Energy Harvesting from Vibration-Thermal Energy Harvesting-Energy Management Techniques-Calculation for Battery Selection

BriefdescriptionofAPImodedataTransmission-Testingthecommunicationbetweencoordinatorand remoteXBee-DesignanddevelopmentofgraphicaluserinterfaceforreceivingsensordatausingC++; A brief review of signal processing techniques for structural health monitoring.

WSN based physiological parameters monitoring system- Intelligent sensing system for emotion recognition-WSN based smart power monitoring system. Digital light processor (DLP)

Text Books

1. Subhas Chandra Mukhopadhyay, Smart Sensors, Measurement and Instrumentation, Springer Heidelberg, New York, Dordrecht London, 2013.
2. Halit Eren, Wireless Sensors and Instruments: Networks, Design and Applications, CRC Press, Taylor and Francis Group, 2006.

Reference Books

1. Uvais Qidwai, Smart Instrumentation: A data flow approach to Interfacing, Chapman and Hall,1st Edition, 2013.

Course Outcomes:

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

1. Understand about smart instrumentation system
2. Acquire knowledge on ZigBee transceivers
3. Design self-diagnosing instrumentation system.
4. Identify the issues in power efficient systems and implement energy management techniques in WSN
5. Design wireless instrumentation systems for the given requirement.

ICOE21 - PRODUCT DESIGN AND DEVELOPMENT (THEORY and PRACTICE)

Course type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 4

Course Objectives

1. The aim of this course is to inculcate into the student the spirit of innovation and entrepreneurship. This is achieved in this course by making the students to develop a marketable product on their own as a group. At the end of this semester course, the students will learn how to know the needs of the society and solve the musing the technical knowledge at their disposal.
2. The students will learn some of the general concepts needed for new product development and simultaneously learn how to interact with the society outside the campus to learn about its needs. They also learn about how to get prototypes fabricated outside the campus.
3. The students will fabricate an alpha prototype and test it for its conformity to the design specifications at the beginning of the next academic session
4. After demonstration of the alpha prototype, they proceed to fabricate a beta prototype that is acceptable in the market-place

Course Content

TOPICS COVERED BY LECTURES

Introduction to product design – Product planning – Identifying customer needs – Project selection – Conceptgeneration–Concepttesting–Conceptselection.Productspecification–Productarchitecture – Industrial design – Robust design. Product development economics – Design for manufacturing – Supply chain design – Intellectual property – Design for environment.

PRACTICAL WORK

Interaction with public outside the campus- identifying customer needs- product selection based on customer needs- concept generation- concept testing.

Identifying fabrication requirements- Identifying fabricators for the project- costing- financial model for the product development-finding outside finance for product development if possible andrequired -patent search for the product.

1. Alpha prototype fabrication and testing-to be submitted at the end of the semester with customer acceptance survey

Course Evaluation

Theoretical and Practical part will be evaluated separately and grades will be awarded. Theoretical component will be evaluated during the semester (50%) and the practical component (50%) will be evaluated at the end of the semester.

Course Outcomes

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

1. Make market surveys for new product development
2. Select an appropriate product design and development process for a given application
3. Plan the entire cycle of new product design and development.
4. Fabricate prototypes of new products and test them.
6. Choose an appropriate agronomy for the product and adopt methods to minimize the cost

Text Books

1. Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, 3rd Edition, Tata McGraw-Hill. (2003)
2. Kevin Otto and Kristin Wood, Product Design, Pearson Education,2003.

References:

1. Journals related to Engineering design.

ICOE22 – MEDICAL IMAGING SYSTEMS

Course type: Open Elective (OE) ***Pre-requisites*:**
No. of Credits: 3

Course Objectives

5. To introduce the methods of medical imaging.
6. To impart knowledge in the physics behind the various imaging techniques.
7. To teach the construction and working of various imaging techniques.
8. To study the methods of image reconstruction

Course Content

Introduction to image processing in medical applications, X-Ray tubes, cooling systems, removal of scatters, Fluoroscopy- construction of image Intensifier tubes, angiographic setup, mammography, digital radiology, DSA.

Need for sectional images, Principles of sectional scanning, CT detectors, Methods of reconstruction, Iterative, Back projection, convolution and Back-Projection. Artifacts, Principle of 3D imaging

Alpha, Beta and Gamma radiation, Radiation detectors, Radio isotopic imaging equipments, Radio nuclides for imaging, Gamma ray camera, scanners, Positron Emission tomography, SPECT, PET/CT.

Wave propagation and interaction in Biological tissues, Acoustic radiation fields, continuous and pulsed excitation, Transducers and imaging systems, Scanning methods, Imaging Modes, Principles and theory of image generation.

NMR, Principles of MRI, Relaxation processes and their measurements, Pulse sequencing and MR image acquisition, MRI Instrumentation, Functional MRI.

Text Books

5. D.N. Chesney and M.O. Chesney, Radio graphic imaging, CBS Publications, New Delhi, 4th Edition, 2005.
6. Dwight G. Nishimura, Lulu, Principles of Magnetic Resonance Imaging, StanfordUniv,2010
7. Flower M.A., Webb's Physics of Medical Imaging, Taylor and Francis, New York, 2ndEdition, 2012.
8. Prince and Links, Medical Imaging Signals and Systems, 2nd Edition, Pearson,2015

Reference Books

5. Rangaraj M. Rangayyan, Biomedical Image Analysis, CRC Press, Boca Raton, FL,2005.
6. Donald W. McRobbice, Elizabeth A. Moore, Martin J. Grave and Martin R. Prince, MRI from picture to proton, Cambridge University press, New York, 2nd Edition,2007.
7. Kavyan Najarian and Robert Splinter, Biomedical signals and Image processing, CRC press, New York, 2nd Edition, 2012.

8. Jerry L. Prince and Jonathan M. Links, Medical Imaging Signals and Systems- Pearson Education Inc., 2nd Edition,2014.

Course Outcomes

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

5. Acquire basic domain knowledge about the various medical imaging techniques.
6. Understand the construction and working of various medical imaging equipments.
7. Provide a foundational understanding of algorithms used in medical imaging
8. Analyze the medical images for diagnosis.

ICOE23 - BUILDING AUTOMATION

Course type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives

1. To introduce the basic blocks of Building Management System.
2. To impart knowledge in the design of various sub systems (or modular system) of building automation.
3. To provide insight into some of the advanced principles for safety in automation.
4. To Design energy management system.

Course Content

Introduction:
Concept and application of Building Management System (BMS) and Automation, requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS.

HVAC system:
Different components of HVAC system like heating, cooling system, chillers, AHUs, compressors and filter units and their types. Design issues in consideration with respect to efficiency and economics, concept of district cooling and heating.

Access control and security systems:
Concept of automation in access control system for safety, Physical security system with components, Access control components, Computer system access control – DAC, MAC, and RBAC.

Fire and alarm system:
Different fire sensors, smoke detectors and their types and CO_2 sensors, Fire control panels, design considerations for the FA system, concept of IP enabled fire and alarm system, design aspects and components of PA system.

CCTV system and energy management system:
Components of CCTV system like cameras, types of lenses, typical types of cables, controlling system, concept of energy management system, occupancy sensors, fans and lighting controller. Introduction to structural health monitoring and methods employed.

Text Books

1. Jim Sinopoli, Smart Buildings, Butterworth-Heinemann imprint of Elsevier, 2nd Edition.,2010.
2. Albert Ting Pat So, WaiLok Chan, Intelligent Building Systems, Kluwer Academic publisher, 3rd Edition, 2012.
3. Reinhold A. Carlson, Robert A. Di Giandomenico, Understanding Building Automation Systems, published by R.S. Means Company,1991.
4. Morawski, E, Fire Alarm Guide for Property Managers, Publisher: KessingerPublishing, 2007.

Reference Books

1. Building Automation: Control Devices and Applications by In Partnership with NJATC (2008).
2. Building Control Systems, Applications Guide (CIBSE Guide) by The CIBSE (2000).
3. Phil Zito., Building Automation Systems a to Z: How to Survive in a World Full of Bas, CreateSpace Independent Pub.” 2016.
4. James Backer, Viktoriya, Leena Greefe., Building Automation: Communication systems with EIB/KNX, LON and BACnet (Signals and Communication Technology), Springer publication. (2018)

Course Outcomes

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

1. Understand the concept behind building automation.
2. Plan for building automation.
3. Design sub systems for building automation and integrate those systems.
4. Learn to design energy efficient system.

MINOR (MI) COURSES

ICMI10 – TRANSDUCER ENGINEERING

Course type: Programme Elective (PE) ***Pre-requisites*:**
No. of Credits: 3

Course Objectives:

1. To expose the students to various sensors and transducers for measuring mechanical quantities.
2. To make the students familiar with the specifications of sensors and transducers.
3. To teach the basic conditioning circuits for various sensors and transducers.
4. To introduce advances in sensor technology.

Course Content:

General concepts and terminology of measurement systems, transducer classification, general input-output configuration, static and dynamic characteristics of a measurement system, Statistical analysis of measurement data.

Resistive transducers: Potentiometers, metal and semiconductor strain gauges and signal conditioning circuits, strain gauge applications: Load and torque measurement, Digital displacement transducer.

Self and mutual inductive transducers- capacitive transducers, eddy current transducers, proximity sensors, tacho-generators and stroboscope.

Piezoelectric transducers and their signal conditioning, Seismic transducer and its dynamic response, photoelectric transducers, Hall effect sensors, Magneto strictive transducers, Basics of Gyroscope.

Introduction to semiconductor sensor, materials, scaling issues and basics of micro fabrication. Smart sensors.

Text Books:

1. John P. Bentley, Principles of Measurement Systems, Pearson Education, 4th Edition, 2005.
2. Doebelin E.0, Measurement Systems - Application and Design, McGraw-Hill, 4th Edition, 2004.
3. S.M. Sze, Semiconductor sensors, John Wiley and Sons Inc., 1994.

Reference Books:

1. Pallas-Areny Ramon, John G. Webster. Sensors and signal conditioning. New York: Wiley, 2001.
2. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India, New Delhi 2011
3. De Silva, Clarence W. Sensors and actuators: Engineering system instrumentation. CRC Press, 2015.
4. Ripka, Pavel, Alois Tipek, eds. Modern sensors handbook. John Wiley and Sons, 2013.
5. Khazan, Alexander D. Transducers and their elements: design and application. Prentice Hall, 1994.
6. Fraden, Jacob. Handbook of modern sensors: physics, designs, and applications. Springer Science and Business Media, 2004.
7. Tumanski, Slawomir. Handbook of magnetic measurements. CRC Press, 2016.
8. Murthy D. V. S, Transducers and Instrumentation, Prentice Hall, 2nd Edition,2011.

9. James W. Dally, Instrumentation for Engineering Measurements, Wiley, 2nd Edition,1993.
10. John G. Webster, Sensors and Signal Conditioning, Wiley Inter Science, 2nd Edition,2008.
11. B.E. Noltingk, Instrumentation Reference Book, Butterworth- Heinemann, Second edition 1995
12. Kirianaki N.V., Yurish S.Y., ShpakN.O., Deynega V.P., Data Acquisition and Signal Processing for Smart Sensors, John Wiley and Sons, Chichester, UK, 2002

Course Outcomes:

On completion of this course, the students will be,

1. Familiar with the basics of measurement system and its input, output configuration.
2. Familiar with both static and dynamic characteristics of measurement system.
3. Familiar with the principle and working of various sensors and transducers.
4. Able to design signal conditioning circuit for various transducers.
5. Able to select proper transducer / sensor for a specific measurement application.

ICMI11 – TEST AND MEASURING INSTRUMENTS

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To give an overview of current, voltage and power measuring electrical, electronics and digital instruments.
2. To expose the students to the design of bridges for the measurement of resistance, capacitance and inductance.
3. To give an overview of test and measuring instruments.

Course Content:

Electrical measurements: General features and Classification of electro mechanical instruments. Principles of Moving coil, moving iron instruments. Extension of instrument range: shunt and multipliers, CT and PT.

Measurement of Power: Electrodynamic wattmeter's, Low Power Factor (LPF) wattmeter, errors, calibration of wattmeter. Single and three phase power measurement, Hall effect wattmeter, thermal type wattmeter.

Different methods of measuring low, medium and high resistances, measurement of inductance and capacitance with the help of AC Bridges, Q Meter.

Digital Measurement of Electrical Quantities: Concept of digital measurement, block diagram Study of digital voltmeter, Digital multimeter, Digital LCR meter, Digital wattmeter and energy meters.

DSO, Function generator, Audio frequency signal generation, Waveform analyzers, Spectrum analyzers.

Text Books:

1. Golding, E.W. and Widdis, F.C., Electrical Measurements and Measuring Instruments, A.H. Wheeler and Co, 5th Edition, 2011.
2. David A. Bell, Electronic Instrumentation and Measurements, Oxford University Press, 3rd Edition, 2013.
3. Shawney A K, A course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Sons. 19th revised edition, 2013.

Reference Books:

1. Cooper, W.D. and Helfric, A.D., Electronic Instrumentation and Measurement Techniques, Prentice Hall, 1st Edition, 2009.
2. Kalsi.H. S, Electronic Instrumentation, Tata McGraw Hill Education Private Limited, 3rd Edition, 2012.

Course Outcomes:

On completion of this course, the students will be,

1. Familiar with various measuring instruments (ammeters, voltmeters, wattmeters, energy meters, extension of meters, current and voltage transformers) used to measure electrical quantities.
2. Able to design suitable DC and AC bridges for the measurement of R, L, C and Frequency measurement.
3. Able to suggest the kind of instrument suitable for typical measurements.
4. Able to use the test and measuring instruments effectively.

ICMI12 – MEASUREMENTS IN PROCESS INDUSTRIES

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
3. To make the students knowledgeable in the design, installation and troubleshooting of process instruments.

Course Content:

Temperature measurement: Introduction to temperature measurements, Thermocouple, Resistance Temperature Detector, Thermistor and its measuring circuits, Radiation pyrometers and thermal imaging.

Pressure measurement: Introduction, definition and units, Mechanical, Electro-mechanical pressure measuring instruments. Low pressure measurement, Transmitter definition types, I/P and P/I Converters.

Level measurement: Introduction, Capacitance pickup, Ultrasonic pickup.

Flow measurement: Introduction, definition and units, classification of flow meters, differential pressure and variable area flow meters, Positive displacement flow meters, Electro Magnetic flow meters.

Hot wire anemometer and ultrasonic flow meters. Calibration and selection of Flow meters

Text Books:

1. Ernest.O. Doebelin and Dhanesh.N. Manik, Doebelin's Measurement Systems, McGraw Hill Education, 6th Edition, 2011.
2. B.G. Liptak, Process Measurement and Analysis, CRC Press, 4th Edition, 2003.
3. Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill, 3rd Edition, 2010.

Reference Books:

1. B.E. Noltingk, Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.
2. Douglas M. Considine, Process / Industrial Instruments and Controls Handbook, McGraw Hill, Singapore, 5th Edition, 1999.
3. Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I andVol II, Gulf Publishing Company, Houston, 2001
4. Spitzer D. W., Industrial Flow measurement, ISA press, 3rd Edition, 2005.
5. Tony.R. Kuphaldt, Lessons in Industrial Instrumentation, Version 2.02, April 2014.

Course outcomes:

On completion of this course, the students will be,

1. Familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
2. Able to select and make measurements of temperature, flow, pressure and level in any process industry.
3. Able to identify or choose temperature, flow, pressure and level measuring device for specific process.

ICMI13 – ESSENTIALS OF CONTROL ENGINEERING

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To expose the students to the fundamentals of feedback control system.
2. To impart the knowledge on different types of control systems representation in pictorial and mathematical forms.
3. To teach the performance characteristics and analysis of control systems in time and frequency domain.

Course Content:

Introduction to control system – Open loop and Closed loop system – Feedback system characteristics – Block diagram reduction techniques – Signal flow graph.

Order and type of system – time domain and frequency domain response of different system characteristics using simulation software – Introduction of stability – Routh Hurwitz stability criteria.

Introduction to root locus – plotting of root locus and stability analysis using simulation software. Introduction to bode and Nyquist plot – Plotting of bode and Nyquist plot using simulation software - Gain Margin and Phase margin calculation.

Introduction to different compensator design – the design of different compensator design using simulation software. PID controller design using simulation software.

Application of control system for different domain with case studies.

Text Books:

1. Dorf, R.C., and Bishop, R.H., Modern Control Systems, Prentice Hall, 13th Edition, 2016.
2. Katsuhiko Ogata Modern Control Engineering, Pearson, 5th Edition, 2009.

Reference Books:

1. Franklin G.F., Powell J.D., Emami-Naeini A., Feedback Control of Dynamic Systems, Pearson, 7th Edition, 2015.
2. B. C. Kuo, F. Golnaraghi, Automatic Control Systems, Wiley Publishers, India, 8th Edition, 2003.
3. Ramakalyan A., Control Engineering- A comprehensive foundation, Vikas Publication, New Delhi, 2004.
4. Norman S. Nise, Control Systems Engineering, Wiley India publications, 4th Edition, 2003.

Course Outcomes:

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

1. Appreciate the importance of feedback control system.
2. Analyze and design the system performance using time domain and frequency domain techniques.
3. Use simulation software for classical control system design and analysis.

ICMI14 – INDUSTRIAL AUTOMATION AND CONTROL

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Objectives:

1. To introduce the importance of process automation techniques.
2. To impart required knowledge in PLC based programming.
3. To introduce to the students to the distributed control system and different communication protocols.

Course Content:

Introduction and overview of Industrial automation – Block diagram of PLC – different types of PLC – Type of input and output – Introduction to relay logic- Application of PLC.

Introduction to Ladder logic programming – Basic instructions – Timer and Counter instruction- Arithmetic and logical instruction – MCR, PID controller and other essential instruction sets - Case studies and examples for each instruction set.

Introduction to high level PLC language – Programming of PLC using simulation software – Real time interface and control of process rig/switches using PLC.

Introduction to DCS and SCADA - Block diagram – function of each component – Security objective – Operation and engineering station interface – Communication requirements.

Development of different control block using DCS simulation software – Real time control of test rigs using DCS. Introduction to HART, Fieldbus and PROFIBUS – Application and case studies of large-scale process control using DCS.

Text Books:

1. John W. Webb and Ronald A. Reis, Programmable Logic Controllers - Principles and Applications, Prentice Hall Inc., New Jersey, 5th Edition, 2002.
2. Lukcas M.P, Distributed Control Systems, Van Nostrand Reinhold Co., New York, 1986.
3. Frank D. Petruzella, Programmable Logic Controllers, McGraw Hill, New York, 4th Edition, 2010.
4. Dr. R. Manikandan, Dr. R. Senthil., Logic and Distributed Control System Sai Publishers
5. John. W. Webb, Ronald A Reis, Programmable Logic Controllers - Principles and Applications, 5th Edition, Prentice Hall Inc., New Jersey, 2003.
6. R.G. Jamkar., Industrial Automation Using PLC SCADA and DCS (PLC and SCADA Book), Global Education Limited; second edition. 2018.

Reference Books:

1. Deshpande P.B and Ash R.H, Elements of Process Control Applications, ISA Press, New York, 1995.
2. Curtis D. Johnson, Process Control Instrumentation Technology, Prentice Hall, New Delhi, 8th Edition, 2005.
3. Krishna Kant, Computer-based Industrial Control, Prentice Hall, New Delhi, 2nd Edition, 2011.

Course Outcomes:

On completion of this course, the students will be familiar with,

1. The process automation technologies.
2. Design and development of PLC ladder programming for simple process applications.
3. The different security design approaches, engineering and operator interface issues for designing distributed control system.
4. The latest communication technologies like HART and Field bus protocol.

ICMI15 - DIGITAL ELECTRONICS

Course type: Minor (MI) ***Pre-requisites*:** -

No. of Credits: 3

Course Objectives:

The subject aims to provide the student with

5. An understanding of number systems, codes and their conversions.
6. The capability to reduce Boolean expression using K-map and tabular methods.
7. The ability to design and analyze combinational and sequential logic circuits for a given problem statement.
8. An understanding of digital hardware, different types of logic families and their characteristics

Course Content:

Review of number systems and logic gates, Algebraic reductions, Binary codes **-**Weighted and non-weighted, number complements, Binary arithmetic, Error detecting and error correcting codes, SOP, POS Canonical logic forms, Karnaugh maps and Quine-McClusky methods, Don't care conditions, minimization of multiple output functions.

Synthesis of combinational functions: Arithmetic Circuits-Adder/ Subtractor, carry look-ahead adder, signed number addition and subtraction, BCD adders. IC adders. Multiplexers, implementation of combinational functions using multiplexers, de-multiplexers, decoders, code converters, Digital ICs for combinational logic circuits.

Sequential Logic: Basic latch circuit, Debouncing of a switch, Flip-Flops: truth table and excitation table, conversion of Flip-flops, integrated circuit flip-flops. Race in sequential circuits, Shift Registers, Counters - Synchronous, Asynchronous, Up-Down, Design of counters.

Analysis of clocked sequential circuits, Design with state equations, Moore and Mealy graphs, State reduction and assignment, Sequence detection, Hazards. Complexity and propagation delay analysis of circuits. Programmable logic devices, Design using Programmable Logic Devices (PLA, PAL, CPLD and FPGA).

Digital Hardware: Logic levels, Realization of logic gates, different logic families (TTL, ECL, CMOS, HC, HCT, ACT and HSCMOS), Logic levels, voltages and currents, fan-in, fan-out, speed, power dissipation. Comparison of logic families, interfacing between different families.

Text Books:

4. M. Morris Mano, Charles Kime, Tom Martin, Logic and Computer Design Fundamentals, Pearson, 5th Edition, 2016.
5. J.P. Uyemura, A First Course in Digital Systems Design: An Integrated Approach, Nelson Engineering, 1999.

6. W. H. Gothmann, Digital Electronics - An Introduction to Theory and Practice, Prentice Hall of India,2nd Edition, 2000

Reference Books:

8. J.M. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall of India, 2nd Edition, 2003.
9. N.H.E. Weste, and K. Eshraghian, Principles of CMOS VLSI Design: A Systems Perspective, Pearson Education Inc., (Asia), 3rd Edition, 2005.
10. S. Brown and Z Vranesic, Fundamentals of Logic Design with VHDL Design, Tata McGraw- Hill ,2002
11. V. P. Nelson, H.T. Nagle, E.D. Caroll and J.D. Irwin, Digital Logic Circuit Analysis and Design, Prentice Hall International, 1995
12. Anil K Maini, Digital Electronics: Principles and Integrated Circuits , Wiley, 2019
13. Thomas L. Floyd, Digital Fundamentals , 11th Edition, Pearson, 2015
14. Ronald J. Tocci, Widmer Neal, Moss Greg, Digital Systems- Principles and Applications,12th Edition, Prentice Hall, 2010

Course outcomes:

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

5. Understand various number systems, conversions and simplify the logical expressions using Boolean functions.
6. Design and develop arithmetic and other special functions using combinational logic circuits and PLDs.
7. Design and develop synchronous and asynchronous for the given problem statement.
8. Understand how logic gates are built from the fundamental semiconductor electronics and be able to select logic ICs from different families based on requirement.

ICMI16 - MICROPROCESSORS AND MICROCONTROLLERS

Course type: Minor (MI) ***Pre-requisites: -***
No. of Credits : 3

Course Objectives

1. To introduce the architecture of 8, 16 and 32-bit microprocessor and microcontroller.
2. To impart microcontroller programming skills in students.
3. To familiarize the students with data transfer and interrupt services.
4. To Familiarize the students with communication protocols for peripheral interfacing

Course Content

Introduction to computer architecture and organization, Architecture of 8-bit, 16-bit, 32-bit and 64-bit microprocessors, CISC/RISC design philosophy, bus configurations, CPU module. Embedded system overview.

Introduction to embedded C and assembly language, instruction set of a typical 8-bit and 16-bit microprocessor, subroutines and stacks, energy efficient ultra-low power modes, programming exercises.

Timing diagrams, Memory families, Flash Vs FRAM, on-chip peripherals- working with IO ports, ADC, comparators, timers, PWM, Watchdog, Low power modes.

Architectures of 8 and 16-bit Microcontrollers, comparison, programming exercises, applications of energy efficient systems.

Serial and parallel data transfer schemes, interrupts and interrupt service procedure. Internal peripherals of microcontrollers – SPI, I2C UART, USB and DNA. Interfacing with RTC, EEPROM and DAC.

Text Books

1. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085 6th Edition, Penram international publishing (India) pvt.Ltd.2013.
2. DouglasV.Hall, Microprocessors and Interfacing-Programming and Hardware, McGraw-Hill, 2nd Edition, 1999.
3. KennethJ.Ayala, The8051Microcontroller, ThomsonDelmarLearning, 3rdEdition, 2004.
4. John H Davies, MSP430 Microcontroller Basics, Newnes, 1st Edition, 2010.

Reference Books

1. Jonathan W Valvano, Embedded Microcomputer Systems: Real Time Interfacing, CENGAGE Learning Custom Publishing, 3rd Edition, 2010.

Course outcomes:

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

1. Understand the various functional blocks of microprocessor and microcontrollers.
2. Understand and write the assembly and C language programs.
3. Interface the peripherals with microprocessors and microcontrollers
4. Design and develop microcontroller-based applications

ICMI17 - MICRO ELECTRO MECHANICAL SYSTEMS

Course Type: Programme Elective (PE) ***Pre-requisites:***
No. of Credits: 3

Course Objectives

1. To introduce the fundamental concepts of MEMS and Micro systems and their relevance to current scientific needs.
2. To introduce the state-of-art micromachining techniques including surface micromachining, bulk micromachining, and related methods.
3. To make the students knowledgeable in the design concepts of micro sensors and micro actuators.
4. To introduce the challenges and limitations in the design of MEMS devices
5. To make the students knowledgeable in computer aided design tools for modeling MEMS device.

Course Content

Introduction, emergence, MEMS application, scaling issues, materials for MEMS, Thin film deposition, lithography and etching.

Bulk micro machining, surface micro machining and LIGA process.

MEMS devices, Engineering Mechanics for Micro System Design – static bending of thin plates, Mechanical vibrational analysis, Thermomechanical analysis, fracture mechanics analysis, Thin film mechanics.

Theory and design: Micro Pressure Sensor, micro accelerometer – capacitive and piezoresistive, micro actuator.

Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

Text Books

1. Tai Ran Hsu, MEMS and Microsystem Design and Manufacture, TataMcGraw Hill, New Delhi2002.
2. Marc Madou, Fundamentals of Micro fabrication, CRC Press, 2nd Edition,2002.
3. Julian W. Gardner and Vijay K. Varadan, Microsensors, MEMS, and Smart Devices, John Wiley and Sons Ltd, 1st Edition, reprinted2007.

Reference Books

1. Elwenspoek, Miko, Wiegerink, R, Mechanical Microsensors, Springer-Verlag Berlin Heidelberg GmbH, 1st Edition,2001.
2. Simon M. Sze, Semiconductor Sensors, John Wiley and Sons. Inc, 1st Edition,2008.
3. Chang Liu, Foundations of MEMS, Pearson Educational limited, 2nd Edition, 2011.
4. Stephen D. Senturia., Microsystem Design, Kluwer Academic Publishers, 2001.
5. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, and V. K. Aatre., Micro and Smart Systems, Wiley-India, 2010.

Course Outcomes

On completion of this course the students will be,

1. Able to understand the fundamental principles behind the working of micro devices/ systems and their applications.
2. Able to knowledgeable in the standard micro fabrication techniques.
3. Able to identify micro sensors and actuators for a specific application.
4. Able to do acquire skills in computer aided design tools for modeling and simulating MEMS devices.