B. Tech. Degree

In

INSTRUMENTATION AND CONTROL ENGINEERING

SYLLABUS FOR

FLEXIBLE CURRICULUM

(For students admitted in 2015-16 onwards)

DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

TAMIL NADU, INDIA.

INSTITUTE VISION

- To provide valuable resources for industry and society through excellence in technical education and research.

INSTITUTE MISSION

- To offer state-of-the-art undergraduate, postgraduate and doctoral programmes.
- To generate new knowledge by engaging in cutting-edge research.
- To undertake collaborative projects with academia and industries.
- To develop human intellectual capability to its fullest potential.

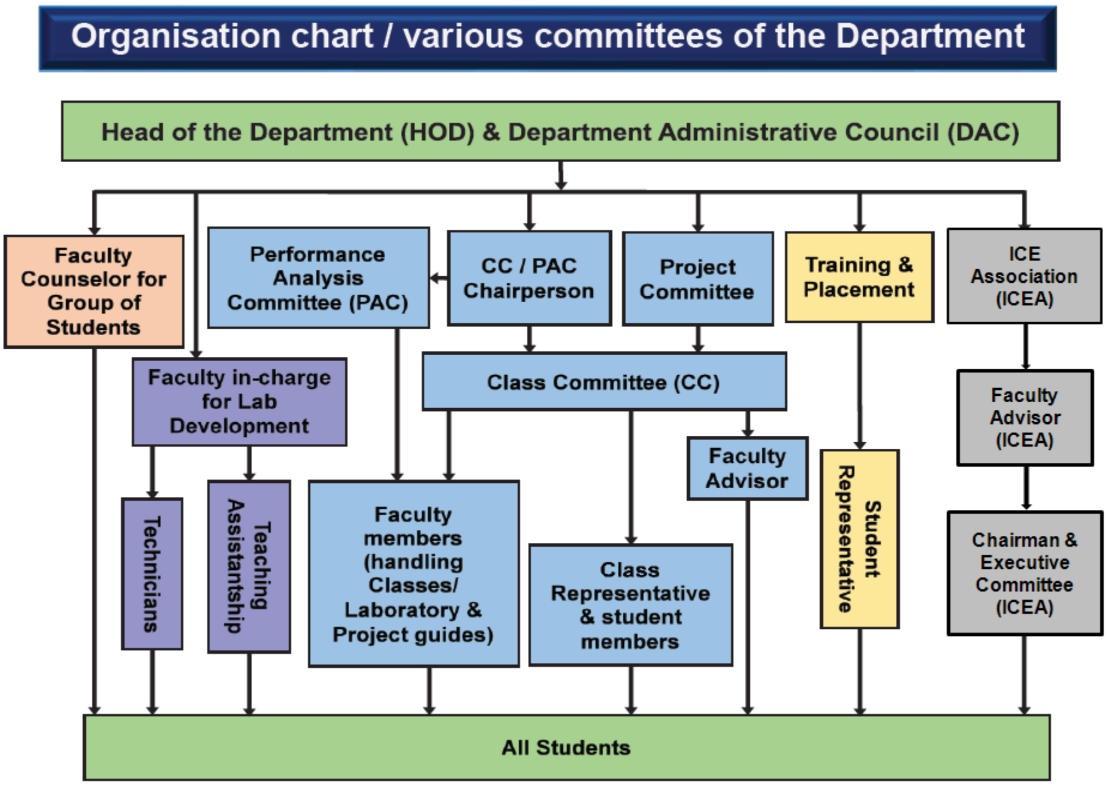
DEPARTMENT VISION

- To constantly strive to make this department a world class school in Instrumentation and Control Engineering.

DEPARTMENT MISSION

- To provide high quality education which inspire the students to realize their aspiration and potential.
- To enhance knowledge, create passion for learning, foster innovation and nurture talents towards serving the society and the country.
- To encourage faculty members to update their knowledge and carryout advanced research in cutting edge technologies.
- To exhibit excellence in research projects and consultancy services, for the benefit of the global community.

Organization Chart / Various Committees of the Department



Programme Educational Objectives (PEOs)

The major objectives of the 4-year B.Tech (ICE) programme offered by the department of Instrumentation & Control Engineering are, to prepare students

1. For employment in the core industrial/manufacturing sector
2. For employment in research and development organizations
3. For employment in electronics & IT/ITES industry
4. For graduate studies in engineering and management
5. For entrepreneurship in the long run

Programme Outcomes (POs)

The students, after undergoing the 4-year B.Tech (ICE) programme,

1. Would have developed an ability to apply the knowledge of mathematics, sciences, and engineering fundamentals to the field of instrumentation & control.
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 electronic systems invariably found in every measurement and instrumentation system.
3. Would have the right knowledge of and exposure to a variety of sensors, data acquisition systems, actuators, and control methodologies to readily provide innovative solutions to the day-to-day problems in the core industry (e.g. processes, power plants, automotive).
4. Would have gained adequate knowledge in microprocessors and microcontrollers, embedded systems, data structures, algorithms, computer programming and simulation software to be able to offer services in IT and management sectors.
5. Would have learnt necessary skills to develop mathematical models, and deploy appropriate techniques and IT tools to design advanced control systems and associated instrumentation for problems dealt in R & D organizations.
6. Would be thoroughly prepared and confident to take up complex problems in the field of I & C and provide sustainable solutions by (i) surveying the literature and patents, (ii) designing and conducting experiments, (iii) interpreting the data, (iv) drawing relevant conclusions, with due consideration and responsibility towards the immediate social, cultural, environmental and legal issues, and (v) documenting the research carried out.
7. Would be able to evaluate and deliver the solutions by optimally utilizing the available resources, including finances and project time, by adapting appropriate resource management techniques.
8. Would be competent to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
9. Would be proficient in English language (spoken and written) in order to communicate effectively on complex engineering activities on a global scale, make comprehensive reports and presentations, and give and receive clear instructions.
10. Would have committed to be professionally ethical.
11. Would pledge to function efficiently in various capacities as members, leaders, and directors in multi-disciplinary teams to accomplish projects of different magnitudes, and
12. Would have recognized the need for engaging themselves in independent and life-long learning in the broadest context of technological change.

CURRICULUM

The total minimum credits required for completing the B.Tech. programme in Instrumentation and Control Engineering is **176.**

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES:

S.No.	COURSE CATEGORY	NO. OF COURSES	NO. OF CREDITS
1.	GENERAL INSTITUTE REQUIREMENT (GIR)	24	68
2.	PROGRAMME CORE (PC)	20	62
3.	ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)	8	16
4.	ELECTIVE COURSES (PE+OE+MI)	10	30
	TOTAL	**62**	**176**

Programme Electives (PE) are offered by the Department of Instrumentation and Control Engineering for students of B.Tech. in Instrumentation and Control Engineering programme. A minimum of nine credits out of the thirty credits allotted for Electives category must be earned from the courses listed in the PE section.

To meet the minimum credit requirement for Electives, the remaining elective courses can be chosen from either PE courses offered by the Department of Instrumentation and Control Engineering, or Open Electives offered by any other Department within National Institute of Technology, Tiruchchirappalli. In addition to the above, the courses registered under B.Tech. (Minor) programme of any other Department, will be considered for Electives category.

I. GENERAL INSTITUTE REQUIREMENT (GIR)

1. MATHEMATICS

S.No.	Course Code	Course Title	Credits
1.	MAIR11	Mathematics – I	4
2.	MAIR21	Mathematics – II	4
3.	MAIR36	Algebra and Probability Theory	3
4.	MAIR43	Numerical Methods	3
		Total	**14**

2. PHYSICS

S.No.	Course Code	Course Title	Credits
1.	PHIR11	Physics- I	3
2.	PHIR13	Physics- II	4
		Total	**7**

3. CHEMISTRY

S.No.	Course Code	Course Title	Credits
1.	CHIR11	Chemistry- I	3
2.	CHIR13	Chemistry- II	4
		Total	**7**

4. COMMUNICATION

S.No.	Course Code	Course Title	Credits
1.	HSIR11	English for Communication	3
2.	HSIR12	Professional Communication	3
		Total	**6**

5. HUMANITIES

S.No.	Course Code	Course Title	Credits
1.	HSIR13	Industrial Economics and Foreign Trade	3
		Total	**3**

6. PROFESSIONAL ETHICS

S.No.	Course Code	Course Title	Credits
1.	HSIR14	Professional Ethics and Human Values	3
		Total	**3**

7. ENERGY AND ENVIRONMENTAL ENGINEERING

S.No.	Course Code	Course Title	Credits
1.	ENIR11	Energy and Environmental Engineering	2
		Total	**2**

8. BASIC ENGINEERING

S.No.	Course Code	Course Title	Credits
1.	CEIR11	Basics of Civil Engineering	2
2.	MEIR11	Basics of Mechanical Engineering	2
		Total	**4**

9. ENGINEERING GRAPHICS

S.No.	Course Code	Course Title	Credits
1.	MEIR12	Engineering Graphics	3
		Total	**3**

10. ENGINEERING PRACTICE

S.No.	Course Code	Course Title	Credits
1.	PRIR11	Engineering Practice	2
		Total	**2**

11. INTRODUCTION TO COMPUTER PROGRAMMING

S.No.	Course Code	Course Title	Credits
1.	CSIR11	Basics of Programming	3
		Total	**3**

12. BRANCH SPECIFIC COURSE

S.No.	Course Code	Course Title	Credits
1.	ICIR15	Introduction to Instrumentation and Control Systems Engineering	2
		Total	**2**

13. SUMMER INTERNSHIP

S.No.	Course Code	Course Title	Credits
1.	ICIR16	Internship / Industrial Training / Academic Attachment (2 To 3 Months Duration During Summer Vacation)	2
		Total	**2**

Each student should undergo industrial training / internship for a minimum period of two months during the summer vacation of third year. Attachment with an academic institution within the country (CFTIs such as IISc / IITs / NITs / IIITs, etc.) or university abroad is also permitted in place of industrial training. The course will be evaluated at the beginning of the fourth year (VII semester) by assessing the report and seminar presentations.

14. PROJECT WORK

S.No.	Course Code	Course Title	Credits
1.	ICIR17	Project Work	6
		Total	**6**

15. COMPREHENSIVE VIVA

S.No.	Course Code	Course Title	Credits
1.	ICIR18	Comprehensive Viva-Voce Examination	3
		Total	**3**

Note: A Student can appear for Comprehensive Viva-Voce Examination only after completing all the Programme Core (PC) courses.

16. INDUSTRIAL LECTURE

S.No.	Course Code	Course Title	Credits
1.	ICIR19	Industrial Lecture	1
		Total	**1**

A minimum of five lectures of two hours duration by industry experts will be arranged by the Department. The evaluation methodology, will be based on objective type questioning at the end of each lecture.

17. NSS/NCC/NSO

S.No.	Course Code	Course Title	Credits
1.	SWIR11	NSS/NCC/NSO	0
		Total	**0**

II. PROGRAMME CORE (PC)

LIST OF ESSENTIAL PROGRAMME CORE COURSES			
S.No.	**Course Code**	**Course Title**	**Credits**
1.	ICPC10	Engineering Mechanics	3
2.	ICPC11	Sensors and Transducers	3
3.	ICPC12	Materials Science	3
4.	ICPC13	Thermodynamics and Fluid Mechanics	4
5.	ICPC14	Circuit Theory	4
6.	ICPC15	Digital Electronics	3
7.	ICPC16	Signals and Systems	3
8.	ICPC17	Industrial Instrumentation	3
9.	ICPC18	Analog Signal Processing	3
10.	ICPC19	Electrical and Electronic Measurements	3
11.	ICPC20	Microprocessors and Microcontrollers	3
12.	ICPC21	Control System – I	4
13.	ICPC22	Instrumentation Practices in Industries	3
14.	ICPC23	Principles of Communication Systems	3
15.	ICPC24	Control System – II	3
16.	ICPC25	Process Control	4
17.	ICPC26	Product Design and Development (Theory)	2
18.	ICPC27	Product Design and Development (Practice)	2
19.	ICPC28	Analytical Instrumentation	3
20.	ICPC29	Logic and Distributed Control System	3
		TOTAL	**62**

III. ELECTIVE COURSES

1. PROGRAMME ELECTIVES (PE)

Students pursuing B.Tech. in Instrumentation and Control Engineering should complete at least three courses from the Programme Electives listed below.

LIST OF PROGRAMME ELECTIVES				
S.No.	**Course Code**	**Course Title**	**Pre-Req.**	**Credits**
1.	ICPE10	Optical Instrumentation	-	3
2.	ICPE11	Medical Instrumentation	-	3
3.	ICPE12	Micro Electro Mechanical System	ICPC11	3
4.	ICPE13	Automotive Instrumentation	ICPC11 ICPC17	3
5.	ICPE14	Instrumentation and Control for Power Plant	ICPC17 ICPC25	3
6.	ICPE15	Instrumentation and Control for Petrochemical Industries	ICPC17 ICPC25	3
7.	ICPE16	Instrumentation and Control for Paper Industries	ICPC17 ICPC25	3
8.	ICPE17	Instrumentation for Agricultural and Food Processing Industries	ICPC11 ICPC17	3
9.	ICPE18	Piping and Instrumentation Diagram	ICPC17 ICPC25	3
10.	ICPE19	Measurement Data Analysis	ICPC19	3
11.	ICPE20	Building Automation	-	3
12.	ICPE21	Digital Control Systems	ICPC16 ICPC21 ICPC24	3
13.	ICPE22	Neural Networks and Fuzzy Logic	-	3
14.	ICPE23	Non Linear Control	ICPC21 ICPC24	3

15.	ICPE24	System Identification and Adaptive Control	ICPC24	3
16.	ICPE25	Fault Detection and Diagnosis	-	3
17.	ICPE26	Computational Techniques in Control System	ICPC21 ICPC24	3
18.	ICPE27	Process Modelling and Optimization	ICPC24 ICPC25	3
19.	ICPE28	Control System Components	ICPC21 ICPC25	3
20.	ICPE29	Network Control System	ICPC23 ICPC29	3
21.	ICPE30	Digital Signal Processing	ICPC16	3
22.	ICPE31	Power Electronics	ICPC18	3
23.	ICPE32	Embedded System	ICPC15 ICPC20	3
24.	ICPE33	Smart and Wireless Instrumentation	ICPC20 ICPC23	3
25.	ICPE34	Digital Image Processing	ICPE29	3
26.	ICPE35	Multi Sensor Data Fusion	ICPC24	3
27.	ICPE36	Medical Imaging System	ICPE34	3
28.	ICPE37	Industrial Data Communication	ICPC29	3
29.	ICPE38	Energy Harvesting Techniques	-	3
30.	ICPE39	Smart Materials and Systems	-	3
31.	ICPE40	Hydraulics and Pneumatics	-	3
32.	ICPE41	Internet of Things System Design	ICPC20	3
33.	ICPE42	Software Design Tools for Sensing and Control	-	3
34.	ICPE43	Industrial Electric Drives	ICPE31	3

2. OPEN ELECTIVES (OE)

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

LIST OF OPEN ELECTIVES			
S.No.	**Course Code**	**Course Title**	**Credits**
1.	ICOE10	Building Automation	3
2.	ICOE11	Project Engineering and Management	3
3.	ICOE12	Medical Instrumentation	3
4.	ICOE13	Micro Electro Mechanical System	3
5.	ICOE14	Measurement and Control	3
6.	ICOE15	Industrial Measurements	3
7.	ICOE16	Virtual Instrument Design	3
8.	ICOE17	Neural Networks and Fuzzy Logic	3
9.	ICOE18	Network Control Systems	3
10.	ICOE19	Control System	3
11.	ICOE20	Energy Harvesting Techniques	3
12.	ICOE21	Internet of Things	3
13.	ICOE22	Intellectual Property Rights	3
14.	ICOE23	Smart Materials and Systems	3

3. MINOR (MI)

Students registered for B.Tech. (Minor) in Instrumentation and Control Engineering can opt to study any five of the courses listed below.

LIST OF COURSES FOR B.Tech. (MINOR) PROGRAMME			
S.No.	**Course Code**	**Course Title**	**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

However, the above courses will also be offered as an open elective for other branch students.

Note: Student should be allowed a minimum of 50% of the total electives of a programme from Open electives and Minor, if so desired.

IV. ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

LIST OF ESSENTIAL PROGRAMME LABORATORY REQUIREMENT			
S.No.	**Course Code**	**Course Title**	**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	Instrumentation Laboratory	2
6.	ICLR15	Microprocessors and Microcontrollers Laboratory	2
7.	ICLR16	Control Engineering Laboratory	2
8.	ICLR17	Industrial Automation and Process Control Laboratory	2
		TOTAL	**16**

Note: students can register for 2 laboratory courses during one session along with the regular courses (PC / PE / OE / MI)

V. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

1. A student is eligible to register for B.Tech. (Honours) degree provided the student has:
   i. Registered at least for twelve theory courses and two ELRs in the second year.
   ii. Consistently obtained a minimum GPA of 8.5 in the first four sessions.

2. The student should Continue to maintain the same GPA of 8.5 in the subsequent sessions (including the Honours courses)

3. A student can obtain B.Tech. (Honours) degree
   i. On completion of three additional theory courses specified for the Honours degree of the programme.
   ii. On completion of all the courses registered, in the first attempt during the four years of study.

LIST OF ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)				
S.No.	**Course Code**	**Course Title**	**Co-Req.**	**Credits**
1.	ICHO10	Design of Sensors and Transducers	ICPC11	3
2.	ICHO11	Instrumentation System Design	ICPC17 ICPC22	3
3.	ICHO12	Micro System Design	ICPE12	3
4.	ICHO13	Advanced Control System Design	ICPC21 ICPC24	3
5.	ICHO14	Advanced Process Control	ICPC21 ICPC25	3
6.	ICHO15	Optimal and Robust Control	ICPC21 ICPC24	3
7.	ICHO16	Electronics for Sensor Design	ICPC14 ICPC18 ICPC20	3
8.	ICHO17	System On Chip	ICPC18	3

ICPC10 - ENGINEERING MECHANICS

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

Course Learning Objectives:

1. To introduce the fundamentals of mechanics and machines to the instrumentation and control engineering students.
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 elements 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 vibrations of 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, W. 'Mechanical Science', 3rd edition. 2006, Wiley-Blackwell Publishing. ISBN:978-1-4051-3794-2*
2. *Shames, Irving H., 'Engineering Mechanics: Statics and Dynamics', 4th edition, Pearson Education, 2006 ISBN: 978-81-7758-123-2.*

3. *Beer, Ferdinand P., Johnston, E. Russel, Mazurek, David F., and Cornwell, Phillip J. 'Vector Mechanics for Engineers: Statics and Dynamics', McGraw- Hill Education (India), 11th edition. 2015, ISBN: 978-12-5906-291-9.*

Course outcomes:

After successfully completing this course, the student will be able to

1. Identify 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.

ICPC11 - SENSORS AND TRANSDUCERS

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

Course Learning Objectives:

1. To expose the students to various sensors and transducers for measuring mechanical quantities.
2. To understand the specifications of sensors and transducers.
3. To learn 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.

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, Magnetostrictive transducers, Basics of Gyroscope.

Digital displacement sensors, Fibre optic sensor, Semiconductor sensor and 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 & Sons Inc., 3rd Edition, 2006.*

Reference Books:

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

Course outcomes:

After successfully completing this course, the student will be

1. Familiar with the basics of measurement system and its input, output configuration of measurement system.
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.

ICPC12 - MATERIAL SCIENCE

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

Course Learning Objectives:

To develop an understanding of the basic principles of Material Science and apply those principles to engineering applications.

Course Content:

Introduction to crystal structure of materials, density computations, polymorphism and allotropy, Miller indices for crystallographic planes and directions, isotropy and anisotropy with respect to material properties. X-ray diffraction for determination of crystal structure. Defects in solids: point, line and planar defects and their effect on properties of materials. Phase diagrams, mono component and binary systems, Interpretation of phase diagrams, the Gibbs phase rule, the iron-carbon system.

Development of micro structure-equilibrium and non-equilibrium cooling. Time- temperature-transformation curves and their applications. Mechanical properties of materials: elasticity, elastic and plastic behaviour, stress-strain relationship, fatigue and creep, strengthening mechanisms and fracture. Thermal properties: heat capacity, thermal expansion, thermal conductivity and thermal stresses.

Electrical properties of materials: Electron energy band structures for solid materials, conduction in terms of band and atomic bonding models. Intrinsic and extrinsic semiconductors, the temperature variation of conductivity and carrier concentration. Electrical properties of polymers. Dielectric behaviour, Ferro electricity and Piezoelectricity.

Magnetic properties, diamagnetic, paramagnetic, Ferromagnetic, anti-ferromagnetic, ferromagnetic materials and their applications. Influence of temperature on magnetic characteristics of materials. Superconductivity in materials Optical properties of materials: Absorption, transmission, refraction, reflection; opacity and translucency in materials Absorption, transmission, refraction, reflection; opacity and translucency in materials. Mechanism of photon absorption. Environmental effect on materials.

Zone refining for purification of materials, Synthesis and growth of Group-III-V compounds and their applications. Selection of specific materials required for instrumentation devices, sensors, pumps, valves, pipelines and coatings.

Text Books:

1. *Callister W.D.,Materials Science and Engineering: An introduction, 6th Edition, John Wiley & Sons Inc., New York 2002.*
2. *Raghavan V. Materials Science and Engineering – A first course, 5th Edition, Prentice Hall, New Delhi, 2004.*
3. *Van Vlack, LH, Elements of Materials Science and Engineering, 6th Edition, Addison – Wesley Singapore, 1989.*

Reference Books:

1. *Askeland D.R. The Science and Engineering of Materials, 6th Edition, Chapman and Hall,London, 2010.*
2. *Smith W.F.and Hashemi J., Foundations of Materials Science and Engineering, 4th Edition, Mc Graw Hill, United States, 2005*

Course outcomes:

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

1. Understand the geometry and crystallography of crystalline materials.
2. Interpretation of phase diagram and iron-carbon system.
3. Define various mechanical properties and the associated testing methods.
4. Define electrical, magnetic and optical properties of materials.
5. Select suitable materials for specific instrumentation devices.

ICPC13 - THERMODYNAMICS AND FLUID MECHANICS

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

Course Learning Objectives:

To develop and understanding of

1. The principles of work and energy, design principles and analysis of thermo-fluid systems.
2. The physical properties of fluids and their consequences on fluid flow.
3. The conservation principles of mass, linear momentum, and energy for fluid flow.
4. The basic forces and moments acting on simple profiles and shapes in an inviscid, steady fluid flow.

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, 7th edition, McGraw Hill, New York, 1997.*
2. *Ojha C.S.P., Berndtsson R., Chandramouli P.N., Fluid Mechanics and Machinery, Oxford University Press,2010.*
3. *Streeter V.L. and Wylie E.B., 'Fluid Mechanics', 9th edition, McGraw Hill, New York, 1997.*

Reference Books:

1. *Van Wylen G.A., Fundamentals of classical Thermodynamics, 4thEdition, John Wiley and Sons,1994.*
2. *Cengal Y.A., Bogles M.A., Micheal Boles, Thermodynamics, 2ndedition, McGraw Hill Book Company, 1994.*
3. *Nag P.K., Engineering Thermodynamics, 2nd Edition, Tata McGraw Hill, 1995.*
4. *Crowe C.T., Elger D.F., Williams B.C., Roberson J.A., Engineering Fluid Mechanics 9th Edition, John Wiley & Sons, 2009.*

Course outcomes:

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

1. Understand various thermodynamic cycles and apply them to heat engines.
2. Quantify the properties of fluids.
3. Know the principles of operation of some of the widely used fluid machinery.

ICPC14 - CIRCUIT THEORY

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

Course Learning Objectives:

1. To introduce and impart problem solving techniques, through linear passive electrical circuits, useful for other core and elective courses of the department.
2. To introduce algorithmic and computer-oriented methods for solving large scale circuits.

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, Maximum Power 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 – Behaviour 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. & Durbin, Engineering Circuit Analysis, McGraw Hill Publications, 8th edition, 2013.*
2. *Ramakalyan, A., Linear Circuits: Analysis & Synthesis, Oxford Univ. Press, 2005.*

Reference Books:

1. *Van Valkenburg, Network Analysis, Prentice Hall, 3rd Edition, 2006*
2. *Van Valkenburg, M.E., Introduction to Modern Network Synthesis, Wiley, 1960.*

Course outcomes:

At the end of the course student will be able to

1. Analyze the basic concepts of A.C and D.C circuits using the network theorems
2. Find transient and frequency response of the electrical circuits.
3. Realize two port networks.

ICPC15 - DIGITAL ELECTRONICS

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

Course Learning Objectives:

The subject aims to provide the student with

1. An understanding of number system, 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 and different types of logic families

Course Content:

Review of number systems and logic gates, Algebraic reductions, Binary codes -Weighted and non-weighted, number compliments, 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, Complexity and propagation delay analysis of 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. Programmable logic devices,Design using Programmable Logic Devices (ROM,PLA,PAL,FPGA).

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

Text Books:

1. *M.M. Mano, Digital Logic and Computer Design, Pearson, 4th Edition, 2014.*
2. *J.P. Uyemura, A First Course in Digital Systems Design, Brooks/Cole Publishing Co.*
3. *W. H. Gothmann, "Digital Electronics - An Introduction to Theory and Practice", Prentice Hall of India, 2000*
4. *C. H. Roth, Fundamental s of Logic design, Jaico Publishers, 1998.*
5. *S. Brown and Z Vranesic, Fundamentals of Logic Design with VHDL Design, Tata McGraw-Hill , 2000*

6. *V. P. Nelson, H.T. Nagle, E.D. Caroll and J.D. Irwin, Digital Logic Circuit Analysis and Design, Prentice Hall International, 1995*

Reference Books:

1. *J.M. Rabaey, Digital Integrated Circuits: A Design Perspective, 2nd Edition, Prentice Hall of India, 2003.*
2. *N.H.E. Weste, and K. Eshraghian, Principles of CMOS VLSI Design: A Systems Perspective, 3rd Edition, Pearson Education Inc., (Asia), 2005*

Course outcomes:

On completion of the course, the student will

1. Understand how digital and logic computing is built from the fundamentals of semiconductor electronics and learn the capability to use abstractions to analyze and design digital electronic circuits.
2. Gain knowledge on the basic logics and techniques related with digital computing.
3. Develop expertise to design and implement various complicated digital systems to be applicable for signal measurement and processing.

ICPC16 - SIGNALS AND SYSTEMS

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

Course Learning Objectives:

1. This course introduces the student to general theory of signals and systems and makes the student familiar with the mathematical tools available to analyze the signals and systems in the first three units.
2. The student is introduced to random phenomena in real-world and the mathematical models to classify them in the fourth unit.
3. The use of pseudo-random signals in identifying systems is introduced in the fifth unit of the course.

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, 3rd Edition, 1987..*
2. *Oppenheim A.V., Wilsky and Nawab, Signals and Systems, Pearson India Education Services Private limited India, 2nd Edition, 2016.*
3. *Chen C.T., Systems and Signal Analysis - A Fresh Look, Oxford University Press India, 3rd Edition, 2004, ISBN100195756617.*

Reference Books:

1. *Cooper G.R and Mc Gillem C.D, Probabilistic Methods of Signals and System Analysis, Oxford University Press, 3rd Edition, 1999.*
2. *Chesmond, Wilson and Lepla, Advanced Control System Technology, Viva Books, 1st Edition, 1998.*
3. *Ziemer R.E., Tranter W.H., and Fannin D.R., Signals and Systems: Continuous and Discrete, Prentice Hall, 4th Edition, 1998.*

Course outcomes:

1. The student will get a general understanding of continuous-time and discrete-time signals and systems.
2. The student will be able to analyze signals and systems using transforms.
3. The student will be able to classify random signals using statistical concepts and characterize systems using pseudo-random signals.

ICPC17 - INDUSTRIAL INSTRUMENTATION

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

Course Learning Objectives:

To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.

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, Mechanical and electrical methods of level measurement.

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, 4th Edition, CRC Press, 2003.*
3. *Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill, 3rd Edition, 2010.*

Reference Books:

1. *B.E.Noltingk, Instrumentation Reference Book, 2ndEdition, Butterworth Heinemann, 1995.*
2. *Douglas M. Considine, Process / Industrial Instruments & Controls Handbook, 5th Edition, McGraw Hill, Singapore, 1999.*
3. *Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I &Vol 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:

After successfully completing this course, the student will be

1. Familiar with the different temperature measurement techniques used in process industries.
2. Familiar with various flow instrumentation used in industrial flow measurement.
3. Able to understand the working principle of different pressure transmitters and level sensors used in industries.
4. Able to identify or choose temperature, flow, pressure and level measuring device for specific process measurement.

ICPC18 - ANALOG SIGNAL PROCESSING

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

Course Learning Objectives:

Real word looks for system-level design skills in both analog and digital domains. The main focus of the course is analog system design. It will cover the design and test of practical circuits based on op-amps and other ICs.

Real world signals are processed for a variety of reasons, such as to remove unwanted noise, to correct distortion, to make them suitable for transmission. Analog signal processing unit comprises of various blocks which includes the theory of amplification, filtering, analysing, transmitting and reproducing the analog signals.

This course is designed to expose students to

1. The fundamental to the theory of analog signal processing
2. Various analog signal processing circuits and hardware implementation.

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 passive filters, 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 form generators, oscillators.

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

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. *Gabel R.A. and Robert R.A., Signals and Linear Systems, John Wiley and Sons, 3rd Edition, 2009*

Reference Books:

1. *Cooper G.R and Mc Gillem C.D, Probabilistic Methods of Signals and System Analysis, Oxford University Press, 3rd Edition, 1998.*
2. *Arie F.Arbel, Analog Signal Processing and Instrumentation, Cambridge University press, 1984.*

Course outcomes:

On completion of this course, the student will understand

1. The fundamental to the theory of analog signal processing
2. Various analog signal processing circuits and hardware implementation

ICPC19 - ELECTRICAL AND ELECTRONIC MEASUREMENTS

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

Course Learning Objectives:

The course is designed to equip the students to understand the design and principle of common electrical, electronic and digital instruments for measurement of electrical and electronic quantities.

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 electronic instruments, Digital voltmeter, Analog and digital multi-meters, Digital frequency meters. Digital LCR meter, Q-Meter, Digital wattmeter and energy meters.

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

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, 2014.*

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:

After successfully completing this course, the student will be

1. Familiar with various measuring instruments (ammeters, voltmeters, wattmeter's, energy meters extension of meters, current and voltage transformers) used to detect electrical quantities.
2. Able to design suitable DC and AC bridges for the measurement of R, L, C and Frequency measurement.
3. Able to understand the analog and digital measurements.
4. Familiar with the operation and usage of various analyzing instruments.

ICPC20 - MICROPROCESSORS AND MICROCONTROLLERS

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

Course Learning Objectives:

The aim of this course is to study the architecture, programming language and interfacing concepts of a microprocessors and microcontrollers.

Course Content:

Introduction to computer architecture and organization, Architecture of 8-bit and 16 bit microprocessors, bus configurations, CPU module.

Introduction to assembly language and machine language programming, instruction set of a typical 8-bit and 16 bit microprocessor, subroutines and stacks, programming exercises.

Timing diagrams, Memory families, memory interfacing, programmable peripheral interface chips, interfacing of input-output ports, programmable interval timer.

Serial and parallel data transfer schemes, interrupts and interrupt service procedure. Programmable interrupt controller. Programmed and interrupt driven data transfer. Programmable DMA controller, UART.

Architectures of 8051 Microcontroller, Bus configuration, programming the ports, Timers, serial interface, LCD interface, ADC interface, interrupt programming, Programming exercises, Applications.

Text Books:

1. *Ramesh Goankar, Microprocessor Architecture, Programming and applications with the 8085, 6th Edition, Penram International Publishing house, 2013.*
2. *Douglas V. Hall, Microprocessors and Interfacing-Programming and Hardware, 2nd Edition, Mc Graw Hill, 1999.*
3. *Kenneth J.Ayala, The 8051 Micro controller, Thomson Delmar Learning, 3rd Edition, 2004.*

Reference Books:

1. *Myke Predko, Programming and Customizing the 8051 micro controller, Tata-McGraw Hill, 3rd reprint 2007.*
2. *N.Mathivanan, Microprocessors, PC Hardware and Interfacing, PHI Learning Private Limited, 10th reprint 2013.*

Course outcomes:

Student will be able to

1. Understand the various functional blocks of microprocessor and microcontrollers.
2. Understand and Write an assembly language programming
3. Interface the peripherals with microprocessor and microcontrollers.

ICPC21 - CONTROL SYSTEM - I

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

Course Learning Objectives:

1. To teach a variety of classical methods and techniques for designing control systems.
2. To introduce and teach the iterative nature of most designs in order to achieve working 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 & Performance Specifications in Time-Domain, Design of Lead, Lag, and PID Controllers using Root Locus.

Frequency Response Methods, Nyquist's Stability Criterion, Bode Plots, Performance Specifications in Frequency-Domain, Stability Margins.

Design of Lag and PID controllers in Frequency Domain, Design of Lag-Lead Controllers using time-domain and frequency-domain methods.

Text Books:

1. *Dorf, R.C., & Bishop, R.H., Modern Control Systems, 13th edition, Prentice Hall, 2016.*
2. *Franklin, G.F., David Powell, J., & Emami-Naeini, A., Feedback Control of Dynamic Systems, 7th edition, Prentice Hall, 2014.*

Reference Books:

1. *Nise, N.S., Control Systems Engineering, 7th edition, Wiley, 2015.*
2. *Dutton, K., Thompson, S., & Barralough, B., The Art of Control Engineering, Prentice Hall, 1997.*

Course outcomes:

1. The student understands translating physical phenomena into corresponding mathematical descriptions, and applies appropriate tools to analyze the behaviour of systems.
2. The student learns to deploy classical graphical tools to analyze and design control systems in time-domain.
3. The student understands that the frequency domain is a complementary point of view, and learns to design control systems in frequency-domain.
4. The student is exposed to the PID controllers prevalent in the Industry.

ICPC22 - INSTRUMENTATION PRACTICES IN INDUSTRIES

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

Course Learning Objectives:

1. To expose the students to requirement of standards and calibration techniques, safety mechanisms in instruments used in process industries.
2. To understand and solve the 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.

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, 2nd Edition, Butterworth Heinemann, 1995.*
2. *Liptak B.G, Process Measurement and Analysis, 4th Edition, Chilton Book Company, Radnor, Pennsylvania, 2003.*
3. *Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I &Vol II, Gulf Publishing 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 & Sons, INC., Publication,2009.*

Course outcomes:

The students will be

1. In a position to select the appropriate instrument for a given process measurement problem.
2. In a position to identify and classify the use of instruments in process industries according to the safety practices in industry.
3. In a position to prepare a instruments specification and understand the procedure and process involved in project documentation.

ICPC23 - PRINCIPLES OF COMMUNICATION SYSTEMS

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

Course Learning Objectives:

To introduce the principles of analog and digital communication systems involving different modulation and demodulation schemes.

Course Content:

Amplitude modulation: AM, generation of AM waves, demodulation, DSBSC, SSB, VSB, FDM, AM receivers, Optical Communication, Microwave communications and Satellite Communications

Angle modulation: Phase and Frequency modulation, Single-tone, narrow band, wide band and multi tone FM, generation and demodulation of FM, FM receivers.

Pulse Analog modulations: Sampling theorem, Time Division Multiplexing, PAM, Pulse time modulation.

Pulse Digital modulation: PCM, Measure of Information, Channel capacity, DPCM, DM, Digital multiplexers.

Noise: SNR, Noise in AM and FM receivers, Noise in FM reception, FM Threshold effect, Pre-emphasis and de-emphasis, Noise in PCM system, Destination SNR in PCM system with quantization and channel noise, output SNR in DM system.

Text Books:

1. *S.Haykin, Communication Systems, 4th Edition, John Wiley & Sons, 2000.*
2. *H.Taub & D.Schilling, Principles of Communication System, 3rd Edition, Tata McGraw Hill, 2007*
3. *J.S.Beasley&G.M.Miler, Modern Electronic Communication, 9th Edition, Prentice-Hall, 2008.*

Reference Books:

1. *B.P.Lathi,Modern Analog And Digital Communication systems, 3rd Edition, Oxford University Press, 2007*
2. *B.Carlson, Communication Systems, 3rd Edition, McGraw Hill Book Co., 1986.*
3. *Sam Shanmugam, Digital and analog Communication Systems, John Wiley, 1985.*

Course outcomes:

Student can able to

1. Develop an understanding of need for modulation and generation & detection of Analog modulation techniques.
2. Explore AM and FM Super heterodyne receiver working principle.

3. Discuss the techniques for generation and detection of pulse Analog modulation techniques
4. To understand the basic operation involved in PCM like sampling, quantization & encoding and are able to calculate and derive entropy and channel capacity.
5. To compare different communication system with various modulation techniques in the presence of noise by analytically.

ICPC24 - CONTROL SYSTEM – II

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

Course Learning Objectives:

1. To introduce and teach advanced methods and techniques of linear system analysis and design from modern and digital control theory, and emphasize their interrelation.
2. To introduce mathematical modeling, analysis, and design of a larger class of systems in a unified framework.

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

Digital Control Systems, Closed-loop Feedback Sampled-Data Systems, Stability Analysis, Implementation of Digital Controllers.

Text Books:

1. *Hespanha, J.P., Linear Systems Theory, Princeton Univ. Press, 2009.*
2. *Brogan, W.L., Modern Control Theory, 3rd edition, Prentice Hall, 1990.*

Reference Books:

1. *Sontag, E.D., Mathematical Control Theory, 2nd edition, Springer Verlag, 2014.*
2. *Hinrichsen, D., & Pritchard, A.J., Mathematical System Theory – I, Springer, 2010.*

Course outcomes:

1. The student is exposed to an appropriate modern paradigm for the study of larger scale multi-input-multi-output systems.
2. The student understands the importance of linear algebra and matrix theory in designing practical control systems.
3. The student is motivated to study more general systems and their stability using Lyapunov's theory.

4. The student learns to implement modern control systems using a digital computer in the loop.

ICPC25 - PROCESS CONTROL

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

Course Learning Objectives:

1. To introduce students the terminology, concepts and practices of process modeling and automatic process control.
2. To impart knowledgeable in the design of control systems and controller tuning for processes.

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, multiposition, 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.

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 & II order systems, with and without valve, measuring element dynamics.

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

Advanced control system: Cascade control, ratio control, feed forward control. Over-ride, split range and selective control. Multivariable process control, interaction of control loops. 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, 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.*

Reference Books:

1. *C.L.Smith and A.B Corripio., Principles and Practice of Automatic Process Control, John Wiley and Sons, New York, 2nd Edition 1998.*
2. *Paul W.Murril, Fundamentals of Process Control Theory, 3rd Edition, ISA press, New York, 2000.*

Course outcomes:

At the end of the course student will be able to

1. To identify the type of process and different control schemes.
2. To design PID controller for any process adopting suitable tuning methodology
3. To understand different control strategies and control loops in distillation column and boilers.

ICPC26 - PRODUCT DESIGN AND DEVELOPMENT (THEORY)

Course type: Programme Core (PC) ***Pre-requisites:*** -
No. of Credits: 2

Course Learning 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 two 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. In this semester 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.

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.. patent search for the product.

SUMMER VACATION WORK

Students shall actively get information about fabrication of their product prototype, especially if it involves outside fabrication units. If they have decided on the final design, they may start work on their alpha prototypes.

Course Evaluation:

Only the theoretical component will be evaluated during this semester. The practical component is evaluated at the end of the next semester.

Text Books:

1. *Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, 3rd Edition, Tata McGraw Hill.*
2. *Kevin Otto and Kristin Wood, Product Design, Pearson Education, 2003.*

ICPC27 - PRODUCT DESIGN AND DEVELOPMENT (PRACTICE)

Course type:	Programme Core (PC)	***Pre-requisites:***	ICPC26
No. of Credits:	2		

Course Learning 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 two 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. In this semester the students will fabricate an alpha prototype and test it for its conformity to the design specifications. After demonstration of the alpha prototype, they proceed to fabricate a beta prototype that is acceptable in the market-place.

Practical work:

1. Alpha prototype fabrication and testing
2. Beta prototype fabrication and customer acceptance survey

Course outcomes:

After this two semester course:

1. The student will know how to make market surveys for new product development
2. The student will know the entire cycle of new product design and development.
3. The student will know how to fabricate prototypes of new products and test them.

ICPC28 - ANALYTICAL INSTRUMENTATION

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

Course Learning Objectives:

This course teaches the student about the analysis of materials which is an important requirement of process control and quality control in industry. The objective of this course is to make the student understand the basic principles used in various analytical methods. The student is then exposed to the various instruments used in the analysis of materials.

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. 2006.*
2. *Ewing, G.W., Instrumental Methods of Analysis, 5th Edition, McGraw Hill, Singapore, 1992.*
3. *Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi,1999.*

Reference Books:

1. *Liptak, B.G. Process Measurement and Analysis, 4th Edition, CRC Press, Washington, 2003.*
2. *Considine, D.M. Process/Industrial Instruments and Controls Handbook, 4th Edition, McGraw Hill, Singapore, 1993.*
3. *Sherman, R.E. and Rhodes L.J., Analytical Instrumentation, ISA Press, New York, 1996.*

Course outcomes:

After successfully completing this course,

1. The student learns the relevance of material sampling and analysis in process control and quality control in industry.
2. The student knows the various physical principles behind the various widely used analytical methods in the industry.
3. The student becomes familiar with the various analytical instruments used widely in the industry.

ICPC29 - LOGIC AND DISTRIBUTED CONTROL SYSTEM

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

Course Learning Objectives:

1. To introduce the importance of process automation techniques.
2. To impart required knowledge in PLC based programming.
3. To expose to distributed control system and different communication protocols.

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 (DAS) 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 programme using above instruction sets for simple applications.

PLC Data manipulation instruction - Arithmetic and comparison instruction- Skip, MCR and 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 FCU diagram for simple control applications. Introduction to HART and Field bus protocol.

Text Books:

1. *John W. Webb and Ronald A Reis, Programmable Logic Controllers - Principles and Applications, 4th Edition, Prentice Hall Inc., New Jersey, 1999..*
2. *Lukcas M.P Distributed Control Systems, Van Nostrand Reinhold Co., New York, 1986.*
3. *Frank D. Petruzella, Programmable Logic Controllers, 5th Edition, McGraw Hill, New York, 2016.*

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, 8th Edition, Prentice Hall, New Delhi, 2005.*

3. *Krishna Kant, Computer-based Industrial Control, Prentice Hall, New Delhi, 2009.*

Course outcomes:

At the end of the course, student will be familiar with

1. The popular 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.

ICPE10 - OPTICAL INSTRUMENTATION

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

Course Learning Objectives:

1. To expose the students the basics of optical sources and detectors, optical fiber and fiber optic sensors.
2. Industrial applications of fiber optic sensor 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 vaporisation, calculation of power requirements. Laser gyroscope.

Text Books:

1. *Djafar.K.Mynbaev, Lowell.L.Scheiner, Fiber-Optic Communications Technology, 1/e, Pearson Education Pte. Ltd., 2008.*
2. *R.P.Khare, Fibre Optics and Optoelectronics, Oxford Press, July 2004.*
3. John M. Senior ,Optical Fiber Communication , 3rd Edition, *Pearson Education, 2009.*

Reference Books:

1. *Wilson and Hawkes, Opto Electronics - An Introduction, 3rd Edition, Prentice Hall, New Delhi, 2003.*
2. *Bhattacharya P, Semiconductor Optoelectronics, 2nd Edition, Prentice Hall, New Delhi, 2002.*

3. *Culshaw B. and Dakin J.(Eds.), Optical Fibre Sensors Vol I, II and III, Artech House, 1989.*
4. *Fukuda, Optical Semiconductor Devices,1/e, John Wiley, 2005.*
5. *Kasap, Optoelectronics and Photonics: Principles and practices, 2/e, Pearson Education, 2012.*

ICPE11 - MEDICAL INSTRUMENTATION

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

Course Learning Objectives:

1. This course gives a brief introduction to the instrumentation for measuring and analyzing the physiological parameters related to the human anatomy.
2. The present syllabus is organized taking into considerations the development of Instrumentation technology in the field of medicine for health care industry. To provide a window of applications of instrumentation and automation in agriculture and food processing industries.

Course Content:

Electro physiology: Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, cardiovascular dynamics, electrode theory, bipolar and uni-polar electrodes, surface electrodes, physiological transducers. Systems approach to biological systems.

Bioelectric potential and cardiovascular measurements: Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and specific direct measurement techniques. Heart sound measurement - stethoscope, phonocardiograph. EMG - Evoked potential response, EEG, foetal monitor. ECG, phonocardiography, vector cardiograph, impedance cardiology, cardiac arrhythmia's, pace makers, defibrillators.

Respirator and pulmonary measurements and rehabilitation: Physiology of respiratory system, respiratory rate measurement, artificial respirator, oximeter, hearing aids, functional neuromuscular simulation, physiotherapy, diathermy, nerve stimulator, Heart lung machine, Haemodialysis, ventilators, incubators, drug delivery devices, therapeutic applications of the laser.

Patient monitoring systems: Intensive cardiac care, bedside and central monitoring systems, patient monitoring through telemedicine, implanted transmitters, telemetering multiple information. Sources of electrical hazards and safety techniques.

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

Text Books:

1. *Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall of India, New Delhi,2007.*
2. *Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology, 4th edition, Cbs Publishers & Distributors, Prentice Hall 2000.*

Reference Books:

1. *L.A.Geddes and L.E.Baker, Principles of Applied Biomedical Instrumentation, 3rd Edition, John Wiley, New York, 2009.*
2. *R.S.Kandpur, Handbook of Biomedical Instrumentation, 2^{nd} edition, Tata McGraw Hill, New Delhi, 2003.*

Course Outcomes:

After successfully completing this course, the student will be able to

1. Understand the basic knowledge of physiology.
2. Explore the occurrence of potential and operation of cardiovascular measurements.
3. Understand the basic knowledge on respiratory and pulmonary measurements.
4. Discuss the methods used for monitoring the patients.
5. Be familiar with the various imaging systems used in the hospitals. An understanding on various food processing methods, important parameter to be monitored and controlled, various parameters to be analysed and monitored.

ICPE12 - MICRO ELECTRO MECHANICAL SYSTEMS

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC11
No. of Credits: 3

Course Learning Objectives:

The objective of this course is

1. To introduce the concepts of microelectromechanical devices.
2. To introduce the state-of-art micromachining techniques including surface micromachining, bulk micromachining, and related methods.
3. To know the design concepts of micro sensors and micro actuators.
4. To acquire knowledge about 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 & Microsystem Design and Manufacture, Tata McGraw Hill, New Delhi 2002.*
2. *Marc Madou, Fundamentals of Micro fabrication, 2/e CRC Press, 2002.*
3. *Julian W. Gardner and Vijay K. Varadan, Microsensors, MEMS, and Smart Devices, John Wiley & Sons Ltd, 2001.*

Reference Books:

1. *Elwenspoek, Miko, Wiegerink, R, Mechanical Microsensors, Springer Science & Business Media, 2001.*
2. *Simon M. Sze, Semiconductor Sensors, Jihn Wiley & Sons, Inc 1994.*
3. *Chang Liu, Foundations of MEMS, Pearson International Edition, 2011.*

Course Outcomes:

At the end of the course student will be able to

1. Gain a fundamental understanding of standard microfabrication techniques.
2. Know the major classes, components, and applications of MEMS devices/systems and to demonstrate an understanding of the fundamental principles behind the operation of these devices/systems.
3. Apply knowledge of microfabrication techniques to design a MEMS device or a microsystem.
4. Acquire skills in Computer aided design tools for modeling and simulating MEMS device.

ICPE13 - AUTOMOTIVE INSTRUMENTATION

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC11, ICPC17
No. of Credits: 3

Course Learning Objectives:

1. Study of Electronic Control Unit.
2. Understanding of various automotive standards and Protocols
3. Implementation of measurement and control strategies in automotive application.

Course Content:

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

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

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

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

Automotive standards and protocols:
Automotive standards like CAN protocol, Lin protocol, flex ray, OBD-II, CAN FD, automotive ethernet etc. Automotive standards like MISRA, functional safety standards (ISO 26262).

System design and energy management:
BMS(battery management system), FCM (fuel control module),principles of system design, assembly process of automotives and instrumentation systems.

Text Books:

1. *William B. Ribbens, “Understanding Automotive Electronics”, 6th ed., 2003.*

Reference Books:

1. *Young A.P., Griffiths, "Automotive Electrical Equipment", ELBS & New Press, 1999.*
2. *Tom Weather Jr. &Cland c. Ilunter, "Automotive computers and control system", Prentice Hall Inc., New Jersey.*
3. *Crouse W.H., "Automobile Electrical Equipment",McGraw Hill Co. Inc., New York,1995.*
4. *Bechhold, "Understanding Automotive Electronic", SAE, 1998.*
5. *Robert Boshe "Automotive Hand Book", Bentely Publishers, 5th ed. Germany, 2005.*

Course Outcomes:

1. Ability to understand electronic control unit.
2. Acquire knowledge of various automotive standards and Protocols.
3. Design aspects of measurement and control strategies in automotive application.

ICPE14 - INSTRUMENTATION AND CONTROL FOR POWER PLANT

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC17, ICPC26
No. of Credits: 3

Course Learning Objectives:

1. To provide a window of applications of instrumentation and automation in power plants.
2. Additionally students know about the various methods of power generation and its control methods.

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 – Boiler – types, 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, P & I diagram of boiler – combined cycle power plant, power generation and distribution.

Measurement in boiler and turbine: Metal temperature measurement in boilers, piping system for pressure measuring devices, smoke and dust monitor, 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 pulverizers. Draught plant: Introduction, natural draught, forced draught, induced draught, power requirements for draught systems. Fan drives and control, control of air flow. 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, sliding pressure mode 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, 2nd Edition, ISA Press, New York, 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 & VI, Pergamon Press, London, 1992.*
3. *David Lindsley, Power-plant Control and Instrumentation: The Control of Boilers and HRSG Systems, IET, London, 2000.*
4. *Jervis M.J, Power Station Instrumentation, Butterworth Heinemann, Oxford, 1993.*
5. *Swapan Basu Ajay Debnath, Power Plant Instrumentation and Control Handbook 1st Edition, Academic Press, 2014.*
6. *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.*

Course Outcomes:

1. An understanding on various power generation process, Important parameter to be monitored and controlled, Various parameters to be analyzed and monitored
2. Various instruments involved in and its controlling process
3. An ability to design and conduct experiments, as well as to analyze and interpret data.

ICPE15 - INSTRUMENTATION AND CONTROL FOR PETROCHEMICAL INDUSTRIES

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC17, ICPC25
No. of Credits: 3

Course Learning Objectives:

1. To provide a window of applications of instrumentation and automation in Petrochemical Industries.
2. Additionally students know about the various methods in Petrochemical Industries and its control methods.

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 & 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 Reinhold Company, New York, 1988.*

Reference Books:

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

Course Outcomes:

1. An understanding on various petrochemical process, important parameter to be monitored and controlled, various parameters to be analyzed and monitored.

2. Various instruments involved in and it’s controlling process.
3. An ability to design and conduct experiments, as well as to analyze and interpret data.

ICPE16 - INSTRUMENTATION AND CONTROL FOR PAPER INDUSTRIES

Course type: Programme Elective (PE) ***Pre-requisites***: ICPC17, ICPC25
No. of Credits: 3

Course Learning Objectives:

1. To describe the paper making process and need for measurement
2. To expose the students to the Instrumentation applied in Paper industries.
3. To learn the control operations 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. *John R. Lavigne, An introduction to paper industry Instrumentation, Miller Freeman Publications, California, 1985 series.*
2. Robert J. McGill, Measurement and Control in Papermaking, Adam Hilger Limited, Bristol, 1980.
3. *John R. Lavigne, Instrumentation Applications for the Pulp and Paper Industry, Miller Freeman Publications, California, 1990.*

Reference Books:

1. *James P. Casey, Pulp & Paper Chemical Technology, John Wiley & Sons, New York, 1981.*
2. *Sankaranayanan P.E, Pulp and Paper Industry – Technology & Instrumentation, Kothari's Deskbook.*
3. *Liptak B.G, Instrument Engineers Handbook, volume 2, Process Control, Third edition, CRC press, London, 1995.*

Course Outcomes:

1. Appreciate the need of instrumentation and control in Paper making.
2. Select suitable sensors for a specific process
3. Design a Controller for paper industries.

ICPE17 - INSTRUMENTATION FOR AGRICULTURAL AND FOOD PROCESSING INDUSTRIES

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC11, ICPC17
No. of Credits: 3

Course Learning Objectives:

1. To provide a window of applications of instrumentation and automation in agriculture and food processing industries.
2. Additionally students know about the various processes involved in Food Processing.

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 & 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. *Process Control Instrumentation Technology, Johnson C. D., 7th Edition, Pearson Education, New Delhi, 2003*
2. *Industrial Instrumentation, D. Patranabis, 3rd edition, Tata McGraw Hill publications, New Delhi*

Reference Books:

1. *Process Instrumentation, and Control Handbook, Considine D. M ., 3rd edition, McGraw Hill International*

2. *Instrument Engineers Handbook, Process Measurement Volume I and Process Control Volume II, Liptak B. G., 3rd edition, Chilton Book Company, 2001*
3. *The literature of Agriculture Engineering, Hall C. W., Olsen W. C., Cornell University Press, 1992*
4. *Fundamentals of Food Process Engineering, Sahu J. K., Narosa Publication, 2013.*

Course Outcomes:

1. An understanding on various food processing methods, important parameter to be monitored and controlled, various parameters to be analysed and monitored.
2. Various instruments involved in Agriculture.
3. Design considerations of agricultural and food processing equipment's.

ICPE18 – PIPING AND INSTRUMENTATION DIAGRAM

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC17, ICPC25
No. of Credits: 3

Course Learning Objectives:

1. Identify ISA symbols and interpret basic flow sheets layout principles.
2. Exhibit comprehension of instrumentation/flow diagram relationships and flow sheet/plot plans/piping/interrelationship.
3. Prepare flow sheets (process and mechanical) diagrams and P&IDs.
4. To provide knowledge on risk, hazard and their assessment techniques in Industry
5. To provide knowledge on Safety in Instrumentation & Control Systems

Course Content:

P&I Diagram objectives. Industry Codes and Standards. Government regulations, Engineering drawings: Block flow diagram (BFD), Process flow diagram (PFD), PFD symbols, Piping and instrumentation diagrams, P&ID symbols. Line numbering, Valve numbering, Equipment identification.

Interpreting P&IDs – equipment: Valves, Vessels, Pumps, Heat exchangers, Compressors, Equipment labeling and identification, KKS numbering system, Smart P&IDs, Softwares used in preparation of P&IDs. Binary logic diagrams and Analog Loop diagrams for simple applications.

Instrument connections: Pipe and pipe fittings, Flanged pipe fittings, Tape red thread pipe fittings, Parallel thread, pipe fittings, Sanitary pipe fittings, Tube and tube fittings, Compression tube fittings, Common tube fitting types and Bending instrument tubing, Instrument installation diagram.

Safety in Instrumentation & Control Systems: Hazardous Area & Material classification as per NEC Standards, Explosion Proof Housing, Encapsulation, Sealing, & Immersion, Purging systems. Intrinsic Safety: - Definition, Designing for intrinsic Safety, Isolation or Encapsulation (Series & Shunt Protective elements, & Zener barrier)

Process safety and Safety Management Systems: Introduction to process safety, risk, risk terminologies, consequence and risk, risk measurement, Process Hazard Analysis (PHA), Hazard and operability study (HaZOp), Safety Integrity Level (SIL), Introduction to IEC61511 standard for Functional safety, protection layers, Safety Instrumented System: function, architecture, safety life cycle, Application of safety system

Text Books:

1. *Instrumentation and Control System Documentation, ISA Publisher. Authors: Frederick Meier and Clifford Meier, 2nd Edition, ISBN-13: 978-193600751 ISBN-10: 1936007517*
2. *The management of control system: Justification and Technical Auditing, N.E. Bhttiha, ISA.*
3. *Mannan S., "Lee's Loss Prevention in the Process Industries", Vol.I, 3rdEd., ButterworthHeinemann, 2004.*
4. *Mannan S., "Lee's Loss Prevention in the Process Industries",Vol.II & III, 3 rd Ed., ButterworthHeinemann, 2005.*

5. *Practical Industrial Safety, Risk Assessment and Shutdown Systems, By Dave Macdonald, Elsevier, 2004.*

Reference Books:

1. *American Society of Mechanical Engineers (ASME)*
   - *ASME Boiler and Pressure Vessel Code. Section VIII – Pressure Vessels*
   - *ASME Standard : ASME B 36.10, B 1.20.1, B16.11, B 16.34, B 16.5*
2. *The Instrumentation, Systems, and Automation Society (ISA)*
   - *ISA 5.1 – Instrumentation Symbols and Identification*
   - *ISA 5.2 – Binary Logic Diagrams for Process Operations*
   - *ISA 5.3 – Graphic Symbols for Distributed Control / Shared Display*
3. *Instrumentation, Logic and Computer Systems*
   - *ISA 84.01 – Application of Safety Instrumented Systems for the Process Industries*
4. *Tubular Exchanger Manufacturers Association (TEMA)*
   - *TEMA Standards*
5. *Government Regulations*
6. *Occupational Safety and Health Administration (OSHA)*
   - *OSHA 29 CFR 1910.119 – Occupational Safety and Health Standards, Process*
7. *Safety Management of Highly Hazardous Chemicals.*
8. *KKS – Kraftwerk Kennzeichen System.*

Course Outcomes:

1. Understanding of P&I Diagrams, standards involved and its preparation.
2. Awareness on the different fittings used for instruments installation and various softwares used for the preparation of P&IDs.
3. Understanding of Process safety, Safety Management Systems and instrumentation system design for hazardous applications.

ICPE19 – MEASUREMENT DATA ANALYSIS

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

Course Learning Objectives:

To expose the students about the methods for estimating errors and uncertainties of real measurements: measurements that are performed in industry, commerce, and experimental research.

Course Content:

General Information about Measurements:
Basic concepts and terms, Metrology and the Basic metrological problems, Classification of measurements, Classification of measurement errors, Presentation of results of measurements; Rules for Rounding off.
Measuring Instruments and their Properties:
Types of measuring instruments, The Concept of an Ideal instrument: Metrological Characteristics of measuring instruments, Standardization of the metrological characteristics of measuring instruments, Dynamic characteristics of measuring instruments and their Standardization. Statistical analysis of the errors of measuring instruments based on data provided by calibration laboratories.

Statistical methods for Experimental Data Processing: Requirements of statistical estimations, Estimation of the parameters of the Normal Distribution, Construction of confidence intervals, Methods for testing Hypotheses about the form of the distribution function of a random quantity, Methods for testing sample homogeneity, Trends in applied statistics and experimental data processing.
Direct measurements: Relation between single and multiple measurements, Identification and elimination of systematic errors, Method for calculating the errors and uncertainties of single measurements, Method for calculating the uncertainty in multiple measurements, Comparison of different methods for combining systematic and random errors.
Indirect measurements: Basic terms and classification, Correlation coefficient and its calculation, the method of reduction, The method of transformation, Errors and uncertainty of indirect measurement results.

Examples of Measurements and Measurement Data Processing:
An indirect measurement of the electrical resistance of a resistor, The measurement of the density of a solid body, The measurement f ionization current by the compensation method, The measurement of power at high frequency, The measurement of voltage with the help of a potentiometer and a voltage divider, Calculation of the uncertainty of a value of the compound resistor.
Combined Measurements:
General remarks about the method of least squares, Measurements with linear equally accurate conditional equations, Reduction of linear unequally accurate conditional equations to equally accurate conditional equations, Linearization of nonlinear conditional equations, Examples of the application of Least squares, Determination of the parameters in formulas from empirical data and construction of calibration curves.

Combining the Results of Measurements:
Introductory remarks, Theoretical principles, Effect of the error of the weights on the error of the weighted mean, Combining the results of measurements in which the random errors predominate, Combining the results of measurements containing both systematic and random errors, Example: Measurement of the activity of the nuclides in a source.

Calculation of the Errors of Measuring Instruments:
The problems of calculating measuring instrument errors, Methods for calculating measuring instrument errors, Calculation of the error of electrical balances (unique instrument), Calculation of the error of voltmeters (mass-produced instrument), Calculation of the error of digital thermometers (mass-produced instrument).

Text Books:

1. *Semyon G. Rabinovich, Measurement Errors and Uncertainities – Theory and Practice, 3rd Edition, Springer Publication, 2005.*
2. *S.V. Gupta, Measurement Uncertainties: Physical Parameters and Calibration of Instruments, Springer 2012.*

Reference Books:

1. *Ifan Hughes and Thomas Hase, Measurements and Their Uncertainties: A Practical Guide to Modern Error Analysis, Oxford University Press, 2010.*
2. *Michael, Grabe, Measurement Uncertainties in Science and Technology, Springer 2005.*

Course Outcomes:

After successfully completing this course, the students will know

1. The importance of estimating measurement inaccuracies.
2. Planning of measurement system, its quality and its cost.

ICPE20 - BUILDING AUTOMATION

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

Course Learning Objectives:

1. To understand the basic blocks of Building Management System.
2. To design various sub systems (or modular system) of building automation.
3. To integrate all the sub systems.

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

Fire &alarm system:
Different fire sensors, smoke detectors and their types, CO and CO2 sensors, Fire control panels, design considerations for the FA system concept of IP enabled fire&alarm system, design aspects and components of PA system.

CCTV system &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 & lighting controller.

EPBX System & BMS subsystem integration:
Design consideration of EPBX system and its components, integration of all the above systems to design BMS.

Text Books:

1. *Jim Sinopoli,"Smart Buildings", Butterworth-Heinemann imprint of Elsevier,2nd ed., 2010.*
2. *Albert Ting Pat So, WaiLok Chan, Intelligent Building Systems, Kluwer Academic publisher,3rd ed., 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. *Albert Ting-Pat So, WaiLok Chan, "Intelligent Building Systems" Kluwer Academic publisher, 3rd ed., 2012.*
2. *Building Automation: Control Devices and Applications by In Partnership with NJATC (2008).*
3. *Building Control Systems, Applications Guide (CIBSE Guide) by The CIBSE (2000).*

Course Outcomes:

After successfully completing this course, the students will be able to

1. Understand basic blocks and systems for building automation.
2. Design different systems for building automation and integrate those systems.

ICPE21 - DIGITAL CONTROL SYSTEMS

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC11, ICPC17, ICPC24
No. of Credits: 3

Course Learning Objectives:

1. Study different transform techniques for digital control
2. Design of discrete controller for continuous system
3. Stability analysis of discrete system

Course Content:

Introduction to digital control
Configuration of basic digital control system, discrete transfer function, discrete model sampled data systems using z- transform, transfer function model, signal analysis and dynamic response, zero-order hold equivalent, introduction to first-order-hold equivalent, transformation between =s‘, =z‘, =w‘ plane, z-Domain description of sampled continuous time systems.

Controller design
Controller Design using transform techniques: Root locus and frequency domain analysis compensator design.

State space theory
Control system analysis using state variable method, vector and matrices, state variable representation, conversion of state variable to transfer function and vice versa, conversion of transfer function to canonical state variable models, system realization, solution of state equations.

State space design
Design using state-space methods: controllability and observability, control law design, pole placement, pole placement design using computer aided control system design (CACSD).

Observer design
Observer design, Deadbeat controller design, Delayed system, controller design for delayed systems.

Stability analysis
Stability analysis and Jury‘s stability criterion, Lyapunov stability analysis to linear systems and discrete systems, Stability improvement by state feedback.

Text Books:

1. *K. Ogata,"Discrete Control Systems", PHI, 2nded. 1995.*
2. *M. Gopal,"Digital Control and state variable methods", TMH, 2nd ed., 2006.*

Reference Books:

1. *Isermann, "Digital Control Systems", Springer-Verlag, 1989*
2. *B. C. Kuo, "Digital Control System", 2nded., 1995*

Course Outcomes:

After successfully completing this course, the students will be able to

1. Design discrete controllers for system in time domain.
2. Design discrete controllers for system in frequency domain.
3. Analyze stability of a discrete system.

ICPE22 - NEURAL NETWORKS AND FUZZY LOGIC

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

Course Learning Objectives:

This course is designed to expose students to fundamentals of neural network and fuzzy logic.

Course Content:

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent techniques 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, defuzzificaiton 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 & Sons Ltd Publications, 3rd edition, 2010.*
2. *Laurene Fausett, Fundamentals of Neural networks, Pearson education, Eight Impression, 2012.*

Reference Books:

1. *S. Haykin, Neural Networks: A comprehensive Foundation, 2nd Edition, Prentice Hall Inc., New Jersey, 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:

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

1. Understand the basic principles of fuzzy logic and neural network.
2. Apply and analyze the neural network and Fuzzy logic for Identification and control design for simple applications.
3. Understand the importance of other intelligent techniques like neuro-fuzzy logic and genetic algorithm.

ICPE23 - NON LINEAR CONTROL

Course type: Programme Elective (PE) ***Pre-requisites*****:** ICPC21, ICPC24
No. of Credits: 3

Course Learning Objectives:

1. To investigate how nonlinear systems can be analyzed as well as controlled.
2. To discuss new control methods applied to a number of example domains, including robotics.

Course Content:

Nonlinear system analysis: Concepts of phase plane analysis: phase portraits, construction of phase portrait, singular points, phase plane analysis of linear system and nonlinear system-existence of limit cycles.

Describing function analysis: describing function fundamentals-computing describing functions, common nonlinearities in control systems, describing functions of common nonlinearities, and describing functions analysis of nonlinear systems-stability analysis.

Lyapunov theory: Lyapunov‟s Direct method, stability analysis based on Lyapunov's direct method, Krasovskii's method, variable gradient method.

Lyapunov analysis of Non-Autonomous system. Nonlinear control system design, feedback linearization. Passivity, Nonlinear Control, and Geometric Methods.

Text Books:

1. *Jean-Jacques E. Slotine, "Applied Nonlinear Control", Prentice Hall Englewood Cliffs, New Jersey, 1991*
2. *Khalil, H.K., "Nonlinear Systems," 3/e, Prentice Hall Englewood Cliffs, New Jersey, 2002.*

Reference Books:

1. *Vidyasagar.M, "Nonlinear System Analysis", Prentice Hall Englewood Cliffs, New Jercy, 1978.*
2. *Strogatz, S. H., "Nonlinear Dynamics & Chaos, with Applications to Physics, Biology, Chemistry and Engineering," 2/e, Westview Press, 2014.*

Course Outcomes:

Upon completing this course, the students

1. Have a different view to the behaviour of a general system.
2. Are introduced to various methods of describing nonlinear systems and analyzing some of
3. Their Intrinsic properties in a qualitative manner.
4. Are exposed to the general stability theory of Lyapunov

5. Learn various control system design techniques particularly applicable to nonlinear systems.

ICPE24 – SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC24
No. of Credits: 3

Course Learning Objectives:

1. To describe the different phases that constitute the process of building models, from design identification experiment to model validation.
2. To study parametric and nonparametric model structure different system identification methods and estimation techniques.
3. Expose students to the design of adaptive control methods.

Course Content:

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.

Nonparametric model estimation: 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, determination of model order.

Prediction-Error Model Structures: Parametric estimation using one-step ahead prediction error model structures and estimation techniques (Least Square (LS)- convergence, consistency, Bias, Instrumental Variable, Correlation function LS, generalized LS) for ARX, ARMAX, Box-Jenkins, FIR, Output Error models. Residual analysis for determining adequacy of the estimated models. Recursive system identification

Adaptive Control: Stability Issues in Time-varying Systems, Stability of an Adaptive Systems, Direct and Indirect adaptive control, Self-tuning regulators, MRAC-MIT rule, Lyapunov theory, Adaptive gain calculation, Auto-tuning techniques.

Adaptive Smith predictor control, Auto-tuning and self-tuning Smith predictor. Case study-Online and offline Identification and design of adaptive control for different process.

Text Books:

1. *L.Ljung, System Identification: Theory for the User, 2nd Edition, Prentice-Hall, 1999.*
2. *Torsten Soderstrom and Petre Stoica. "System Identification", Systems and Control Engineering. Prentice Hall International", 1989*
3. *Kannan Moudgalya, " Digital Control", JohnWiley & Sons, Ltd, 2007*
4. *O.Nelles, Nonlinear System Identification, Springer-Verlag, Berlin, 2001.*

Reference Books:

1. *Y.Zhu, Multivariable System Identification for Process Control, Pergamon, 2001.*
2. *Karel J. Keesman," System Identification, an introduction", Springer, 2011.*
3. *Åstrom and Wittenmark, " Adaptive Control", Dover Publications INC, Second Edition,*

2008.

4. *S. Sastry and M. Bodson, Adaptive Control: Stability, Convergence, and Robustness, Prentice-Hall, 1989.*

Course Outcomes:

Upon completing the course, the student should have understood

1. Model structure & order determination for a unknown process
2. Estimation techniques for parametric & nonparametric models
3. Adaptive control schemes and how to design adaptive controller for time varying systems

ICPE25 - FAULT DETECTION AND DIAGNOSIS

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

Course Learning Objectives:

To learn basic principle of Faulty detection and diagnosis.

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 structured 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, 2nd Edition, Macel Dekker, 1998.*
2. *Rolf Isermann, Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance, Springer Verlag, 2006.*

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, FaultTolerant 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:

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

1. Know about different type of faults occurred in a system.
2. Understand Mathematical analysis of different faults.
3. Understand Structured and directional concepts techniques for FDI design.

ICPE26 - COMPUTATIONAL TECHNIQUES IN CONTROL SYSTEM

Course type: Programme Elective (PE) ***Pre-requisites***: ICPC21, ICPC24
No. of Credits: 3

Course Learning Objectives:

1. To emphasize the importance of control system design in the current computer era and teach the interdisciplinary necessity of linear algebra, control theory, and computer science.
2. To describe and develop 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 cost Indian edition available including CD ROM).*
2. *G.H. Golub & C.F. Van Loan, Matrix Computations, 4/e, John Hopkins University Press, 2007 (Low cost 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*

Course Outcomes:

At the end of the course student acquires skills in

1. Numerical solutions of state equations and frequency response computations.

2. Numerical algorithms for controllability, observability, and stability
3. Numerical solutions for conditioning of Lyapunov and algebraic Riccati equation
4. Large-scale solutions of control problems.

ICPE27 - PROCESS MODELLING AND OPTIMIZATION

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC24, ICPC25
No. of Credits: 3

Course Learning Objectives:

1. Identify the models related with various systems.
2. Apply different types of optimization techniques.
3. Study and analysis of nonlinear control strategy.

Course Content:

Modeling of systems:
Thermal system, hydraulic system, reactor system.

Data driven modelling:
Boiler and heat exchanger, evaporator, distillation column and spray dryer.

Objective function formulation:
Investment cost, equipment cost, operational and capitalized costs in objective functions, time value of money, profitability, application of these concepts to thermal insulation, rate of production, thermal system, hydraulic system, reactor system.

Optimization techniques and applications:
Single and multivariable optimization, line programming, sequential quadratic programming and reduce gradient optimization techniques and applications, introduction to geometric programming and dynamic programming.

Advanced controllers:
Model based controllers (self-tuning & model reference adaptive controller), optimal controller using Kalman filter, model predictive controller.

Intelligent controllers:
Expert systems &expert controllers (AI based), fuzzy controllers, artificial neural networks & ANN controller, neuro-fuzzy control system, neuro-MPC.

Text Books:

1. *Singiresu S. Rao, “Engineering Optimization Theory and Practices”, John Wiley & Sons, 4th ed., 2009*
2. *F. G. Shinskey,”Process Control Systems”, McGraw-Hill, 3rd ed. 1996.*

Reference Books:

1. *T. F. Edgar, D. M. Himmelblau, “Optimization of chemical Processes”, McGraw-Hill International Edition.*
2. *W.L. Luyben, “Process modeling, simulation & control for chemical engineers”, McGraw Hill, 2nd ed.,1990.*

3. *G. Stephanopolous, "Chemical Process Control", Prentice Hall of India, 1984.*
4. *Bela G Liptak, "Instrument Engineers Handbook: Process Control", Chilton, 3rded., 1995.*

Course Outcomes:

1. An ability to apply knowledge of mathematics and science to obtain model of a system.
2. An ability to identify, formulate and solve a problem of optimization of a given plant.
3. Understanding of different non-linear control systems.

ICPE28 – CONTROL SYSTEM COMPONENTS

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC21, ICPC25
No. of Credits: 3

Course Learning Objectives:

The purpose of this course is to acquaint the student with the engineering principles and fundamental characteristics of a number of components used in the implementation of many types of control systems.

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Course Content:

Control System Parameters.

Cams, Gears, Gyros, Potentiometers.

Synchros, Servos, Stepper Motors and Tachometers.

Amplifiers, Modulators & Demodulators.

Relays, Hydraulic and Pneumatic Systems, Valve Characteristics.

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.*

Reference Books:

1. *W. G. Andrew & H. B. William, Applied Instrumentation In The Process Industries, Gulf Professional Publishing, 2/e, 1979.*
2. *B. G. Liptak, Instrument Engineers' Handbook, CRC Press.*

Course Outcomes:

The student is exposed to a comprehensive introduction to the components used in control systems. After successful completion of the course, the student will be

1. familiar with various components used in process control loops
2. able to understand the fundamental principles of components and their characteristics used in control systems

ICPE29 – NETWORK CONTROL SYSTEM

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC23, ICPC29
No. of Credits: 3

Course Learning Objectives:

This course will provide an overview of the tools and techniques that have proven instrumental for studying networked control systems as well as outline potential research directions.

Course Content:

Network Models - graphs, random graphs, random geometric graphs, state-dependent graphs, switching networks.

Decentralized Control - limited computational, communications, and controls resources in networked control systems.

Multi-Agent Robotics - formation control, sensor and actuation models.

Mobile Sensor Networks - coverage control, voronoi-based cooperation strategies.

Mobile communications networks, connectivity maintenance.

Text Books:

1. *Networked Embedded Sensing and Control, edited by P. J. Antsaklis and P. Tabuada, Springer 2006.*
2. *Distributed Control of Robotic Networks, by F. Bullo, J. Cortes, and S. Martinez, Princeton University Press, 2009*.

Reference Books:

1. *Mehran Mesbahi and Magnus Egerstedt, Graph Theoretic Methods in Multiagent Networks, Princeton University Press, 2010.*

Course Outcomes:

1. Review recent applications in control that motivate networked control systems
2. Provide an overview of basic tools from communications, computer science and control theory that can be used as a basis for further studies
3. Review recent results in distributed estimation and control, packet-based estimation and control, control in presence of quantization and time-delay
4. Discuss open research problems and emerging NCS applications

ICPE30 - DIGITAL SIGNAL PROCESSING

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

Course Learning Objectives:

1. To provide better understanding of discrete-time and digital signal in time and frequency domain
2. To provide knowledge to analyse linear systems with difference equations
3. To design and implement FIR and IIR filters with different structures.
4. To introduce DSP processor 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 & Filter Design, Oxford Univ. Press, 2001 (Available as an Indian reprint)*
2. *Proakis, J.G., & Manolakis, D.G., Digital Signal Processing: Principles, Algorithms, & Applications, 3/e Prentice Hall of India, 2007.*

3. *Ifeachor, E.C., & Jervis, B.W., Digital Signal Processing: A Practical Approach, 2/e, Pearson* Education Asia, 2009.

Reference Books:

1. *McClellan, J.H., Schafer, R.W., & Yoder, M.A., DSP First: A Multimedia Approach, 2/e Prentice Hall Upper Saddle River, NJ, 2003.*
2. *Mitra, S.K., Digital Signal Processing: A Computer-Based Approach, 4/e ,McGraw Hill, NY, 2011 (A low-cost Indian reprint is available).*
3. *Embree, P.M., & Danieli, D., C++ Algorithms for Digital Signal Processing, 2/e, Prentice Hall Upper Saddle River, NJ, 1999.*

Course Outcomes:

On completion of this course students will be able to:

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

ICPE31 - POWER ELECTRONICS

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC18
No. of Credits: 3

Course Learning Objectives:

1. This course teaches the student about the theory and applications of power electronics systems for high efficiency, renewable and energy saving conversion systems.
2. The objective is to know the characteristics of different power electronics switches, drivers and selection of components for different applications.
3. The students understand the switching behavior and design power electronics circuits such as DC/DC, AC/DC, DC/AC and AC/AC converters.

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, 4th Edition, Prentice Hall, New Delhi, 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, 5th Edition, Khanna Publishers, 2012.*

Reference Books:

1. *Vedam Subramanyam K, Power Electronics, 2nd Edition,New Age International Publishers, New Delhi, 2012.*
2. *Mohan, Undeland and Robbins, Power Electronics: Converters, Applications, and Design", John Wiley and Sons, New York, 1995.*

3. *Joseph Vithyathil, Power Electronics, McGraw Hill, New York, 1995.*

Course Outcomes:

At the end of the course student will be able

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

ICPE32 - EMBEDDED SYSTEM

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC15, ICPC20
No. of Credits: 3

Course Learning Objectives:

1. To introduce the basic concepts of Embedded Systems.
2. To expose to the principles of an entry level and an advanced level ARM processors.
3. To impart required knowledge in programming an entry level and an advanced level ARM processors based microcontrollers.
4. To provide basic understanding of the concepts of OS and RTOS for embedded systems.

Course Content:

Embedded system architecture, classifications, challenges and design issues; Von-Neumann vs. Harvard architecture, embedded processors and microcontrollers, CISC vs. RISC architecture, different types and selection of microcontrollers for embedded systems design.

ARM Processor based Microcontrollers: ARM Processor – Evolution, Architecture versions, Processor Families, ARM7-TDMI processor – Internal Architecture, Bus Architecture, Instruction Set – ARM state and Thumb state instructions, ALP examples, Software development tools.

LPC214x Microcontrollers and Programming: Internal blocks – Processor, system peripherals, Memory map, VIC, bus system, debug support, User Peripherals, Serial Interfaces, Programming the peripherals using C – examples. Case studies of hardware design and software development.

Cortex-M3 Processor: Processor core, Features, Functional blocks, Nested VIC, memory, Debug Support, Instruction Set Architecture, LPC1768 Microcontroller - peripherals list, features, communication interfaces, Trace, JTAG interface. Case studies.

OS Concepts and types, tasks & 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.

Text Books:

1. *Andrew N. Sloss, Dominic Symes, and Chris Wright, ARM System Developer's Guide: Designing and Optimizing System Software, Morgan Kaufmann Publishers, 2004.*
2. *Trevor Martin, The Insider's Guide to the Philips ARM7-Based Microcontrollers, Hitex (UK) Ltd., 2005.*
3. *Joseph Yiu, The Definitive Guide to ARM Cortex-M3, Elsevier–Newnes publications, II Ed., 2010.*

Reference Books:

1. *ARM Architecture Reference Manual: ARM DDI 01 001,*
2. *LPC214x User Manual, UM10139: NXP Ltd. (2012)*
3. *Cortex-M3 Devices Generic User Guide: ARM DUI, 0552A, ID 121610, 2010*

4. *N. Mathivanan, PC Based Instrumentation: Concepts and Practice, PHI Learning, 2007.*

Course Outcomes:

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

1. Design LPC214x microcontroller based embedded system for simple embedded applications.
2. Develop application programs in C or assembly language for LPC214x microcontroller based simple embedded applications and test the programs using Keil software development tool.
3. Apply the hardware and software design and development techniques they in typical ARM Cortex-M3 processor based systems.
4. Develop application programs for execution under RTOS environment.

ICPE33 - SMART AND WIRELESS INSTRUMENTATION

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC20, ICPC23
No. of Credits: 3

Course Learning Objectives:

To provide the adequate knowledge on smart instrumentation and wireless networks.

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

Tedes IEEE 1412- 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.

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 & Hall; 1st Edn, December 2013.*

Course Outcomes:

At the end of the course, the students will be able to
1. Design self-diagnosing instrumentation system.
2. Understand the issues in power efficient systems.
3. Design wireless instrumentation systems for the given requirement.

ICPE34 - DIGITAL IMAGE PROCESSING

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPE29
No. of Credits: 3

Course Learning Objectives:

1. To understand fundamentals of image processing.
2. To apply various processes on images for image understanding.
3. To study, design and realize various image processing applications.

Course Content:

Introduction and Digital Image Fundamentals:
Introduction toimage 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, Houghtransform, 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 & Woods, “Digital Image Processing”, 3rd ed., Pearson education, 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”, 2nd ed., Thomson Learning, 2001.*
2. *Rangaraj M. Rangayyan, “Biomedical Image Analysis”, CRC Press, 2005.*
3. *Pratt W.K, “Digital Image Processing”, 3rd ed., John Wiley & Sons, 2007.*

Course Outcomes:

1. Apply knowledge of mathematics for image understanding and analysis.
2. Design and analysis of techniques / processes for image understanding.
3. To design, realize and troubleshoot various algorithms for image processing case studies.
4. Select the appropriate hardware and software tools (Contemporary) for image analysis.

ICPE35 - MULTISENSOR DATA FUSION

Course type: Programme Elective (PE) ***Pre-requisites:*** ICPC24
No. of Credits: 3

Course Learning Objectives:

To learn the concepts and techniques used in sensor data fusion.

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

Text Books:

1. *David L. Hall, Mathematical techniques in Multisensor data fusion, Artech House, Boston, 1992.*
2. *R.R. Brooks and S.S.Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998.*

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:

Upon completion of this course the students will be able to

1. Understand the concept of sensor fusion.
2. Apply algorithms for multisensor data fusion.
3. Interpret high performance data structures.

ICPE36 – MEDICAL IMAGING SYSTEM

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPE34
No. of Credits: 3

Course Learning Objectives:

1. To Study the Production of X-rays and its applications to different medical Imaging techniques.
2. To study the different types of Radio diagnostic techniques.
3. To study the special imaging techniques used for visualizing the cross sections of the body.
4. To study the imaging of soft tissues using ultrasound technique.

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, 2005.*
2. *W.Peggy, Roger D.Ferimarch, MRI for Technologists, Mc Graw Hill, New York, 1995.*
3. *Steve Webb, The Physics of Medical Imaging, Taylor & Francis, New York, 2012.*

Reference Books:

1. *Donald W.McRobbice, Elizabeth A. Moore, Martin J.Grave and Martin R.Prince MRI from picture to proton, Cambridge University press, New York 2006.*
2. *Jerry L.Prince and Jnathan M. Links, Medical Imaging Signals and Systems- Pearson Education Inc., 2006.*

3. Kavyan Najarian and Robert Splerstor, Biomedical signals and Image processing, CRC – Taylor and Francis, New York, 2006.

Course Outcomes:

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

1. Get the clear domain knowledge about the various Medical Imaging techniques.
2. Explain the various diagnostic applications of the medical imaging techniques.

ICPE37 - INDUSTRIAL DATA COMMUNICATION

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC29
No. of Credits: 3

Course Learning Objectives:

The objective of this course is to expose students to Communication systems emerged in the field. As the industry is progressing towards adopting these methods to build large scale Automation systems, this course prepares the student to take up such challenges in his Industrial Environment.

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 Ethernet networks, 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 Foundation fieldbus 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, 2nd Edition, Butterworth Heinemann, 1995.*
2. *B.G. Liptak, Process software and digital networks, 3rd Edition, CRC press, Florida.*

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.*

Course Outcomes:

Upon completing the course, the student should have understood the concepts required for building industrial systems.

ICPE38 – ENERGY HARVESTING TECHNIQUES

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

Course Learning Objectives:

To introduce students various energy harvesting methods, power optimization and power converter circuit design for different ambient energy harvesters.

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 nuimorph 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- Wirewound 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 thermoelectrics 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 diffrenet ambient sources.

Text Books:

1. *Shashank Priya Daniel J.Inman, "Energy Harvesting Technologies" springer-verlag New york Inc, 1st Edition, 2008.*
2. *Danick Briand, Eric Yeatman, and Shad Roundy,"Micro energy Harvesting", Wiley-VCH Verlag GmbH & Co,2015.*

Reference Books:

1. *Stephen Beeby,Neil white " Energy Harvesting for Autonomous Systems".artech house ,Norwwood,1 st Edition ,2010.*
2. *Alper Erturk and Daniel J Inman,"Piezlelectric Energy Harvesting",John Viley and Sens.Ltd.publication.,1st Edition ,2011.*

3. *Tom J.Kazmiershi,Steve Beeby,"Energy Harvesting System,Principles,Modelling and Application",springer,Newyork,2011.*

Course Outcomes:

Students will:

1. Be introduced to the concept of ambient energy harvesting techniques
2. Learn how to design optimal power converting circuits for different harvesters
3. Be able to design vibration energy harvester for narrow and wide band excitation
4. Be able to design electromagnetic and thermoelectric energy harvesters

ICPE39 – SMART MATERIALS AND SYSTEMS

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

Course Learning Objectives:

1. To familiarize students with different classes of ceramic and polymeric smart materials; development of actuators and sensors and their integration into a smart structure.
2. To provide the student with knowledge for analysis and design of intelligent structures for aerospace, mechanical, and civil applications using different smart materials.

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 Sensors 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 Behaviour 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 Fibre 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, Kluwer Academic Publishers, 1992.*
2. *Mel Schwartz, Encyclopedia of smart materials, John Wiley and Sons, 2001.*

3. *Srinivasan A.V., Michael McFarland D., Smart Structure analysis and design, Cambridge University Press, 2001*
4. *Culshaw B., Smart structures and Materials, Artech house, 1996*
5. *Leo, D.J. Engineering Analysis of Smart Material Systems, Wiley, (2007).*

Reference Material:

1. *www.iop.org/sms*
2. *www.jim.sagepub.com.*

Course Outcomes:

Upon completion of the course, the student will be able to:

1. Demonstrate knowledge and understanding of the physical principles underlying the behaviour of smart materials.
2. Describe the basic principles and mechanisms of the stimuli-response for the most important smart materials.
3. Demonstrate knowledge and understanding of the engineering principles in smart sensors, actuators and transducer technology.
4. Propose improvement on the design, analysis, manufacturing and application issues involved in integrating smart materials and devices with signal processing and control capabilities to engineering smart structures and products

ICPE40 - HYDRAULICS AND PNEUMATICS

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

Course Learning Objectives:

The objectives of this course are to develop the understanding of the students

1. To provide a sound 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.
5. To introduce the concept of signal processing elements and control.

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. *Fluid Power with applications, Anthony Esposito, Fifth edition pearson education, Inc. 2000.*
2. *Pneumatics and Hydraulics, Andrew Parr. Jaico Publishing Co. 2000.*
3. *Hydraulics and Pneumatics, Dr.Niranjan Murthy and Dr.R.K.Hegde, 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", IInd Edition, Tata McGraw - Hill Education, 2012.*
2. *Shanmugasundaram.K, "Hydraulic and Pneumatic controls", Chand & Co, 2006.*

Course Outcomes:

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

1. Get knowledge about working of hydraulic and pneumatic systems.
2. Become aware about controlling components of hydraulic and pneumatic systems.
3. Have good understanding in selection, preparation and distribution of compressed air.
4. Be capable to compile the design of hydraulic and pneumatic systems and analyze them.
5. Demonstrate the need of pressure and time dependent controls.

ICPE41 – INTERNET OF THINGS SYSTEM DESIGN

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

Course Learning Objectives:

The objectives of this course are to develop the understanding of the students

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 very good overview about the various protocol standards deployed in the Internet of Things (IOT) domain and to make informed choices.
4. To design and develop systems with IoT 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, WiFi, 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 Oppurtunities.

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. *Foundational Elements of an IoT Solution – The Edge, Cloud and Application Development, Joe Biron & Jonathan Follett, Oreilly, First Edition, March 2016.*

2. *Designing Connected Products, 1st Edition, Elizabeth Goodman, Alfred Lui,Martin Charlier, Ann Light, Claire Rowland.*
3. *The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, 2016, Lucas Darnell.*

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 WiFi 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*

Course Outcomes:

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

1. System Design knowledge of Internet of Things
2. Understanding the design architecture of IoT
3. Choice of protocols and deployment in solutions
4. Overview and Design Perspective of IoT based products /services
5. Ensuring IoT with Security and Privacy as applicable

ICPE42 – SOFTWARE DESIGN TOOLS FOR SENSING AND CONTROL

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

Course Learning Objectives:

1. To expose the students to the software tools available for sensor and control system design.
2. To learn and understand 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 and using Coventorwarwe.

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

Software tools for control design: 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, 2011*
2. *Tamara Bechtold, Gabriela Schrag and Lihong Feng, System-level Modeling of MEMS, Wiley-VCH verlag GmbH & Co, 2013*
3. *Holly Moore, MATLAb for Engineers, Pearson Education, 4th edition, 2015*

4. *Brian Hahn and Daniel Valentine, Essential MATLAb for Engineers and Scientists, Elsevier, 3rd edition, 2007.*

Reference Books:

1. *Mehrzad Tabatabaian, COMSOL 5 for Engineers, Mercury Learning & Information, 2015.*
2. *S R Otto and J P Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer-verlag, 2005*
3. *Stephen J Chapman, MATLAB Programming for Engineers, Bookware Companion Series, 2nd edition*
4. *Amos Gilat, MATLAB – An Introduction with Applications, John Wiley & Sons, Inc., 2004*

Course Outcomes:

After successfully completing this course, the student will be

1. Familiar in selecting the software tools for sensor and actuator design.
2. Familiar in design, modelling and simulation of various sensing and actuating mechanisms.
3. Able to design controller and evaluate its performance through simulation.
4. Able to design a controller using state space method and evaluate its performance through simulation.
5. Familiar in selecting and using the hardware for real time implementation of controllers.

ICPE43 - INDUSTRIAL DRIVES

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPE31
No. of Credits: 3

Course Learning Objectives:

To enable the students

1. To evaluate and select a suitable drive for a particular application.
2. To analyze the basic drive system dynamics and arrive at operating point characteristics.
3. To develop the basic design of an electric drive system.

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 & 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 & 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 -2000*

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-1994.*
4. *G. K. Dubey, Power semiconductor controlled drives, Prentice Hall - 1989*

Course Outcomes:

1. Students will be able to select a suitable drive for a particular application.
2. Students will be able to develop basic design of an electric drive system, analyze its steady state stability.

ICOE10 - BUILDING AUTOMATION

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

1. Understand the basic blocks of Building Management System
2. Design various sub systems (or modular system) of building automation
3. Integrate all the sub systems

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 &security system
Concept of automation in access control system for safety, Physical security system with components, RFID enabled access control with components, Computer system access control – DAC, MAC, RBAC.

Fire &alarm system
Different fire sensors, smoke detectors and their types, CO and CO2 sensors, Fire control panels, design considerations for the FA system concept of IP enabled fire&alarm system, design aspects and components of PA system.

CCTV system &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 & lighting controller.

EPBX System & BMS subsystem integration
Design consideration of EPBX system and its components, integration of all the above systems to design BMS.

Text Books:

1. *Jim Sinopoli,"Smart Buildings", Butterworth-Heinemann imprint of Elsevier,2nd ed., 2010.*

Reference Books:

1. *Albert Ting-Pat So, WaiLok Chan, "Intelligent Building Systems" Kluwer Academic publisher,3rd ed., 2012.*

Course Outcomes:

1. Understanding of basic blocks and systems for building automation.
2. Designing different systems for building automation and integrate those systems.

ICOE11 – PROJECT ENGINEERING AND MANAGEMENT

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

1. Understand concept of project engineering and management
2. Understand flow of engineering project and related documentation
3. Awareness to management and financial functions and usage of tools for the same

Course Content:

Introduction to project management
Definition of project purpose - Scope, time, quality and organization structure. Basic and detailed engineering: Degree of automation, Project S curves, manpower considerations, inter-department and inter organization interactions, Multi agency interaction. Types of projects and types of contracts e.g. EPC, BOOT etc.

Project management functions
Controlling, directing, project authority, responsibility, accountability, interpersonal influences and standard communication formats, project reviews. project planning and scheduling, life project engineering and management cycle phases, the statement of work (SOW), projects specifications, bar charts, milestones, schedules, work breakdown structures, cost breakdown structures and planning cycle.

Project cost and estimation
Types and estimates, pricing process, salary and other overheads, man-hours, materials and support costs. program evaluation and review techniques (PERT) and critical path method (CPM), estimating activity time and total program time, total PERT/CPM planning crash times, software‘s used in project management.

Text Books:

1. *W.G. Andrew and H.B. Williams, "Applied instrumentation in process industries" Gulf Professional Publishing, 3rd ed. 2008.*
2. *Harlod Kerzner and Van Nostrand, "Project management: A systems approach to planning scheduling and controlling" Reinhold Publishing, 11th ed., 2010.*

Reference Books:

1. *Bela G Liptak, —Instrument Engineers Handbook: Process Control‖, Chilton, 3rded., 1995.*

Course Outcomes:

1. Understanding of different types of projects and its management.
2. Designing different documents and understanding the tools used.
3. Understanding project management and financial tools.

ICOE12 - MEDICAL INSTRUMENTATION

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

1. This course gives a brief introduction to the instrumentation for measuring and analyzing the physiological parameters related to the human anatomy.
2. The present syllabus is organized taking into considerations the development of Instrumentation technology in the field of medicine for health care industry. To provide a window of applications of instrumentation and automation in agriculture and food processing industries.

Course Content:

Electro physiology: Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, cardiovascular dynamics, electrode theory, bipolar and uni-polar electrodes, surface electrodes, physiological transducers. Systems approach to biological systems.

Bioelectric potential and cardiovascular measurements: Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and specific direct measurement techniques. Heart sound measurement - stethoscope, phonocardiograph. EMG - Evoked potential response, EEG, foetal monitor. ECG, phonocardiography, vector cardiograph, impedance cardiology, cardiac arrhythmia's, pace makers, defibrillators.

Respirator and pulmonary measurements and rehabilitation: Physiology of respiratory system, respiratory rate measurement, artificial respirator, oximeter, hearing aids, functional neuromuscular simulation, physiotherapy, diathermy, nerve stimulator, Heart lung machine, Haemodialysis, ventilators, incubators, drug delivery devices, therapeutic applications of the laser.

Patient monitoring systems: Intensive cardiac care, bedside and central monitoring systems, patient monitoring through telemedicine, implanted transmitters, telemetering multiple information. Sources of electrical hazards and safety techniques.

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

Text Books:

1. *Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall of India, New Delhi,2007.*
2. *Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology, 4th edition, Cbs Publishers & Distributors, Prentice Hall 2000.*

Reference Books:

1. *L.A.Geddes and L.E.Baker, Principles of Applied Biomedical Instrumentation, 3rd Edition, John Wiley, New York, 2009.*
2. *R.S.Kandpur, Handbook of Biomedical Instrumentation, 2nd edition, Tata McGraw Hill, New Delhi, 2003.*

Course Outcomes:

Students are able to

1. Understand the basic knowledge of physiology.
2. Explore the occurrence of potential and operation of cardiovascular measurements.
3. Understand the basic knowledge on respiratory and pulmonary measurements.
4. Discuss the methods used for monitoring the patients.
5. Be familiar with the various imaging systems used in the hospitals. An understanding on various food processing methods, important parameter to be monitored and controlled, various parameters to be analysed and monitored.

ICOE13 - MICRO ELECTRO MECHANICAL SYSTEM

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

The objective of this course is
1. To introduce the concepts of microelectromechanical devices.
2. To introduce the state-of-art micromachining techniques including surface micromachining, bulk micromachining, and related methods.
3. To know the design concepts of micro sensors and micro actuators.
4. To acquire knowledge about 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 & Microsystem Design and Manufacture, Tata McGraw Hill, New Delhi 2002.*
2. *Marc Madou, Fundamentals of Micro fabrication, 2/e ,CRC Press, 2002.*
3. *Julian W. Gardner and Vijay K. Varadan, Microsensors, MEMS, and Smart Devices, John Wiley & Sons Ltd, 2001.*

Reference Books:

1. *Elwenspoek, Miko, Wiegerink, R, Mechanical Microsensors, Springer Science & Business Media, 2001.*
2. *Simon M. Sze, Semiconductor Sensors, Jihn Wiley & Sons, Inc 1994.*
3. *Chang Liu, Foundations of MEMS, Pearson International Edition, 2011.*

Course Outcomes:

At the end of the course student will be able to

1. Gain a fundamental understanding of standard microfabrication techniques.
2. Know the major classes, components, and applications of MEMS devices/systems and to demonstrate an understanding of the fundamental principles behind the operation of these devices/systems.
3. Apply knowledge of microfabrication techniques to design a MEMS device or a microsystem.
4. Acquire skills in Computer aided design tools for modeling and simulating MEMS device.
5. Be familiar with the various imaging systems used in the hospitals. An understanding on various food processing methods, important parameter to be monitored and controlled, various parameters to be analysed and monitored.

ICOE14 - MEASUREMENT AND CONTROL

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Draft (to be modified as required for the purpose)

Course Learning Objectives:

In this course it is aimed to introduce to the students the principles and applications of mechanical measurements and basic control systems in everyday life.

Course Content:

Fundamental & Importance of Instrumentation, types of instruments, selection of instruments, performance of instruments, error in measurement, calibration & standard, Calibration of Instruments: Methods & analysis, Introduction to Transducer & types, Process Instrumentation, recording instruments, indicating & 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 & Thermistor, Thermocouples & 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 flow meter.
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. *Industrial Instrumentation & Control by S. K. Singh.TMH Publication.*

2. *Principles of Industrial Instrumentation, D Patranabis, 3rd edition, Mc Graw hill.*
3. *Introduction to Instrumentation and Control by A. K. Ghosh, 4th edition, PHI publications.*
4. *Instrumentation measurement and analysis, 3rd edition, By Nakra Chaudhari, Mc Grawhill.*
5. *Control Systems Theory and Applications - S. K. Bhattacharya, Pearson.*
6. *Control Systems - N. C. Jagan, BS Publications.*

Reference Books:

1. *Mechanical Measurements - Thomos G. Beckwith & Lewis Back N. Adison Wesely Longman, Harlow.*
2. *Measurement Systems: Application and Design by E. D. Doeblin, McGraw – Hill Publication Control Systems Engineering - I. J. Nagrath and M. Gopal, New Age International (P) Limited, Publishers.*
3. *Control Systems - N. K. Sinha, New Age International (P) Limited Publishers.*

Course Outcomes:

After going through this course the student gets a basic knowledge control systems for process applications.

ICOE15 - INDUSTRIAL MEASUREMENTS

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.

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, Mechanical and electrical methods of level measurement.

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. *Doebelin E.O., Measurement Systems - Application and Design, Tata McGraw Hill publishing company, 5th Edition, 2008.*
2. *Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill, 3rd Edition, 2010.*

Reference Books:

1. *B.E.Noltingk, Instrumentation Reference Book, 2ndEdition, Butterworth Heinemann, 1995.*
2. *B.G.Liptak, Process Measurement and Analysis, 4th Edition, Chilton Book Company, Radnor, Pennsylvania, 2003.*
3. *Douglas M. Considine, Process / Industrial Instruments & Controls Handbook, 5th Edition, McGraw Hill, Singapore, 1999.*
4. *Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I &Vol II, Gulf Publishing Company, Houston, 2001*
5. *Spitzer D. W., Industrial Flow measurement, ISA press, 3rd Edition, 2005*

Course Outcomes:

After successfully completing this course, the student will be

1. Familiar with the different temperature measurement techniques used in process industries.
2. Familiar with various flow instrumentation used in industrial flow measurement.

3. Able to understand the working principle of different pressure transmitters and level sensors used in industries.
4. Able to identify or choose temperature, flow, pressure and level measuring device for specific process measurement.

ICOE16 – VIRTUAL INSTRUMENT DESIGN

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

The aim of the course is to make the student capable of designing a virtual instrument on their own depending on the application.

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 – Circuit Protection - Ground loops, CMRR, Noise Reduction and Isolation, Attenuation – Multiplexing – Digital signal conditioning – IEEE1451 standards – Transducer Electronic Data Sheet (TEDS)

Data Acquisition and Hardware Selection:
Overview of DAQ architecture – Analog IO & 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,Instrumentationa 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. R&D Books, 2000*
2. *Jean Labrosse, MicroC/OS-II – The Real-Time Kernel, 2nd Edition. CMP Books, 2002*

Course Outcomes:

After completing this course, the student will be able to:

1. Choose the 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.

ICOE17 - NEURAL NETWORKS AND FUZZY LOGIC

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

This course is designed to expose students to fundamentals of neural network and fuzzy logic.

Course Content:

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent techniques 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, defuzzificaiton 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 & Sons Ltd Publications, 3rd edition, 2010.*
2. *Laurene Fausett, Fundamentals of Neural networks, Pearson education, Eight Impression, 2012.*

Reference Books:

1. *S. Haykin, Neural Networks: A comprehensive Foundation, 2nd Edition, Prentice Hall Inc., New Jersey, 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:

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

1. Understand the basic principles of fuzzy logic and neural network.
2. Apply and analyze the neural network and Fuzzy logic for Identification and control design for simple applications.
3. Understand the importance of other intelligent techniques like neuro-fuzzy logic and genetic algorithm.

ICOE18 - NETWORK CONTROL SYSTEMS

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

This course will provide an overview of the tools and techniques that have proven instrumental for studying networked control systems as well as outline potential research directions.

Course Content:

Network Models - graphs, random graphs, random geometric graphs, state-dependent graphs, switching networks.

Decentralized Control - limited computational, communications, and controls resources in networked control systems.

Multi-Agent Robotics - formation control, sensor and actuation models.

Mobile Sensor Networks - coverage control, voronoi-based cooperation strategies.

Mobile communications networks, connectivity maintenance.

Text Books:

1. *Networked Embedded Sensing and Control, edited by P. J. Antsaklis and P. Tabuada, Springer 2006.*
2. *Distributed Control of Robotic Networks, by F. Bullo, J. Cortes, and S. Martinez, Princeton University Press, 2009*.

Reference Books:

1. *Mehran Mesbahi and Magnus Egerstedt, Graph Theoretic Methods in Multiagent Networks, Princeton University Press, 2010.*

Course Outcomes:

1. Review recent applications in control that motivate networked control systems
2. Provide an overview of basic tools from communications, computer science and control theory that can be used as a basis for further studies
3. Review recent results in distributed estimation and control, packet-based estimation and control, control in presence of quantization and time-delay
4. Discuss open research problems and emerging NCS applications

ICOE19 – CONTROL SYSTEM

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

1. To teach a variety of classical methods and techniques for designing control systems.
2. To introduce and teach the iterative nature of most designs in order to achieve working 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 & Performance Specifications in Time-Domain, Design of Lead, Lag, and PID Controllers using Root Locus.

Frequency Response Methods, Nyquist's Stability Criterion, Bode Plots, Performance Specifications in Frequency-Domain, Stability Margins.

Design of Lag and PID controllers in Frequency Domain, Design of Lag-Lead Controllers using time-domain and frequency-domain methods.

Text Books:

1. *Dorf, R.C., & Bishop, R.H., Modern Control Systems, 13th edition, Prentice Hall, 2016.*
2. *Franklin, G.F., David Powell, J., & Emami-Naeini, A., Feedback Control of Dynamic Systems, 7th edition, Prentice Hall, 2014.*

Reference Books:

1. *Nise, N.S., Control Systems Engineering, 7th edition, Wiley, 2015.*
2. *Dutton, K., Thompson, S., & Barralough, B., The Art of Control Engineering, Prentice Hall, 1997.*

Course Outcomes:

1. The student understands translating physical phenomena into corresponding mathematical descriptions, and applies appropriate tools to analyze the behaviour of systems.
2. The student learns to deploy classical graphical tools to analyze and design control systems in time-domain.
3. The student understands that the frequency domain is a complementary point of view, and learns to design control systems in frequency-domain.
4. The student is exposed to the PID controllers prevalent in the Industry.

ICOE20 - ENERGY HARVESTING TECHNIQUES

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

To introduce students various energy harvesting methods, power optimization and power converter circuit design for different ambient energy harvesters.

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 nuimorph 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- Wirewound 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 thermoelectrics 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 diffrenet ambient sources.

Text Books:

1. *Shashank Priya Daniel J.Inman, "Energy Harvesting Technologies" springer-verlag New york Inc, 1st Edition, 2008.*
2. *Danick Briand, Eric Yeatman, and Shad Roundy,"Micro energy Harvesting", Wiley-VCH Verlag GmbH & Co,2015.*

Reference Books:

1. *Stephen Beeby,Neil white " Energy Harvesting for Autonomous Systems".artech house ,Norwwood,1 st Edition ,2010.*
2. *Alper Erturk and Daniel J Inman,"Piezlelectric Energy Harvesting",John Viley and Sens.Ltd.publication.,1st Edition ,2011.*
3. *Tom J.Kazmiershi,Steve Beeby,"Energy Harvesting System,Principles,Modelling and Application",springer,Newyork,2011.*

Course Outcomes:

Students will:

1. Be introduced to the concept of ambient energy harvesting techniques
2. Learn how to design optimal power converting circuits for different harvesters
3. Be able to design vibration energy harvester for narrow and wide band excitation
4. Be able to design electromagnetic and thermoelectric energy harvesters

ICOE21 – INTERNET OF THINGS

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

The objectives of this course are to develop the understanding of the students

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 very good overview about the various protocol standards deployed in the Internet of Things (IOT) domain and to make informed choices
4. To design and develop systems with IoT enablement ensuring security and assimilated privacy
5. To introduce the domain specific IoT and their challenges

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, Single Chip Controllers with integrated Processing and Network Core with Hardware CryptoEngines.

Understanding Internet Protocols: Simplified OSI Model, Network Topologies, Standards, Types of Internet Networking – Ethernet, WiFi, 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, Inter-usability and Inter-operability considerations, Understanding Security in IoT Design, Design requirements of IoT Security Issues and challenges, Privacy, Overview of Social Engineering.

Domain specific IoT and their challenges: Illustrated domains-home automation, smart cities, environment, energy, retail, logistics, health and life style.
Case Study of Rapid Internet Connectivity with Cloud Service Providers with CC3200 Controller.

Text Books:

1. *Foundational Elements of an IoT Solution – The Edge, Cloud and Application Development, Joe Biron & Jonathan Follett, Oreilly, First Edition, March 2016*
2. *Designing Connected Products, 1st Edition, Elizabeth Goodman, Alfred Lui, Martin Charlier, Ann Light, Claire Rowland*
3. *The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, 2016, Lucas Darnell*

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 WiFi SOC*
3. *http://www.ti.com/lit/ds/symlink/cc3200.pdf*
4. *Wireless Connectivity Solutions*
5. http://www.ti.com/lit/ml/swrb035/swrb035.pdf
6. *Wireless Connectivity for the Internet of Things – One size does not fit all*
7. http://www.ti.com/lit/wp/swry010/swry010.pdf

Course outcomes

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

1. System Design knowledge of Internet of Things.
2. Understanding the design architecture of IoT.
3. Choice of protocols and deployment in solutions.
4. Overview and Design Perspective of IoT based products /services.
5. Ensuring IoT with Security and Privacy as applicable.

ICOE22 – INTELLECTUAL PROPERTY RIGHTS

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

1. To understand the need of awareness and knowledge about IPR.
2. To understand how IPR contributes to the economic development of the society and in turn the nation.
3. To understand that IP is a law, economics, technology and business.
4. Understand how IPR protection provides an incentive to inventors for further research work and investment in R & D.

Course Content:

Introduction
Nature of Intellectual Property, Patents, Designs, Trademarks and Copyrights, Process of patenting and Development-technological research, Innovation, patenting, development.

International Scenario
International cooperation on Intellectual Property, Procedure for grants of patents, patenting under PCT.

Patent Rights
Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.

New developments in IPR
Administration of Patent system, New developments in IPR, IPR Biological systems, Computers, Software etc., Traditional knowledge, Case studies, IPR and IIT‘s objectives towards learning IPR.

Trademark and patenting
Registered and unregistered trademarks, designs, concepts, idea patenting.

Text Books:

1. *Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd.,2nd ed. 2007.*

Reference Books:

1. *Robert P. Merges, Peter S. Meneil, Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 4th ed., 2007.*
2. *V.K. Ahuja, "Intellectual Property Rights in India", LexisNexis Publishers, 2nd Edition, 2015.*
3. *Vinod V. Sople, "Managing Intellectual Property: The Strategic Imperative", Prentice Hall India Learning Private Limited", 2nd edition, 2010.*
4. *Hiroyuki Odagiri, "Intellectual Property Rights, Development, and Catch Up: An International Comparative Study", OUP Oxford publication, 2010.*

5. *Karla C. Shippey, "International Intellectual Property Rights: Protecting Your Brands, Marks, Copyrights, Patents, Designs and Related Rights Worldwide", World Trade Press, 3rd Edition, 2009.*

Course Outcomes:

1. Understood the importance of IPR.
2. Understood how IPR are regarded as a source of national wealth and mark of an economic leadership in the context of global market scenario.

ICOE23 – SMART MATERIALS AND SYSTEMS

Course Type: Open Elective (OE) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

To provide the student with knowledge for analysis and design of intelligent structures for aerospace, mechanical, and civil applications using different smart materials.

Course Content:

Prerequisites: Foundational knowledge from Principles of mechanics, including basic statics, dynamics, and strength of materials, machine or structure design.

Piezoelectric materials: Properties - Piezoelectricity, characteristics, applications – vibration control, health monitoring, energy harvesting.

Shape-memory materials: Properties, shape memory materials, characteristics, applications – vibration control, shape control, health monitoring.

Electro-Rheological (ER) fluids: Suspensions and ER fluids, ER phenomenon, charge migration mechanism, ER fluid actuators, applications of ER fluids.

Magneto-Rheological (MR) fluids: Composition of MR fluid, applications of MR fluids.

Other smart materials and their applications: Magnetostrictive materials, Electrostrictive materials, Magnetic Shape Memory Alloy, Composites, Ionic Polymer Metal Composites. Bio inspired engineering and micro electro mechanical systems using smart materials.

Text Books:

1. *Mukesh V Gandhi, Brian S Thompson, Smart Materials and Structures, Kluwer Academic Publishers, 1992.*
2. *Mel Schwartz, Encyclopedia of smart materials, John Wiley and Sons, 2001.*
3. *Srinivasan A.V., Michael McFarland D., Smart Structure analysis and design, Cambridge University Press, 2001*
4. *Culshaw B., Smart structures and Materials, Artech house, 1996*
5. *Leo, D.J. Engineering Analysis of Smart Material Systems, Wiley, (2007).*

Reference Material:

1. *www.iop.org/sms*
2. *www.jim.sagepub.com*

Course Outcomes:

Upon completion of this course, the student will

1. Perform detailed analysis of the response of materials and systems exhibiting piezoelectricity and apply principles of dynamic elasticity for structural health monitoring and repair
2. Perform detailed analysis of the response of systems exhibiting shape memory effects
3. Demonstrate knowledge of electro-active fluidic systems
4. Design simple intelligent structural systems to meet specific performance requirements.
5. Communicate principles of mimicking biological systems for engineering solutions.

ICMI10 – TRANSDUCER ENGINEERING

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

1. To expose the students to various sensors and transducers for measuring mechanical quantities.
2. To understand the specifications of sensors and transducers.
3. To learn 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.

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, Magnetostrictive transducers, Basics of Gyroscope.

Digital displacement sensors, Fibre optic sensor, Semiconductor sensor and 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 & Sons Inc., 1994.*

Reference Books:

1. *Murthy D. V. S, Transducers and Instrumentation, Prentice Hall, 2nd Edition, 2011.*
2. *James W.Dally, Instrumentation for Engineering Measurements, Wiley, 2nd Edition, 1993.*
3. *John G.Webster, Sensors and Signal Conditioning, Wiley Inter Science, 2nd Edition, 2008.*

Course Outcomes:

After successfully completing this course, the student will be

1. Familiar with the basics of measurement system and its input, output configuration of measurement system.
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.

ICMI11 – TEST AND MEASURING INSTRUMENTS

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

The course is designed is make the students familiar with test and measuring instruments commonly used.

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 & 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, Q-Meter, Digital wattmeter and energy meters.

CRO, 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:

After successfully completing this course, the student will be

1. Familiar with various measuring instruments (ammeters, voltmeters, wattmeters, energy meters extension of meters, current and voltage transformers) used to detect electrical quantities.
2. Able to design suitable DC and AC bridges for the measurement of R, L, C and Frequency measurement.
3. Able to understand the analog and digital measurements.
4. Familiar with the operation and usage of various analyzing instruments.

ICMI12 – MEASUREMENTS IN PROCESS INDUSTRIES

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.

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, Mechanical and electrical methods of level measurement.

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. *Doebelin E.O., Measurement Systems - Application and Design, Tata McGraw Hill publishing company, 5th Edition, 2008.*
2. *Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill, 3rd Edition, 2010.*

Reference Books:

1. *B.E.Noltingk, Instrumentation Reference Book, 2ndEdition, Butterworth Heinemann, 1995.*
2. *B.G.Liptak, Process Measurement and Analysis, 4th Edition, Chilton Book Company, Radnor, Pennsylvania, 2003.*
3. *Douglas M. Considine, Process / Industrial Instruments & Controls Handbook, 5th Edition, McGraw Hill, Singapore, 1999.*
4. *Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I &Vol II, Gulf Publishing Company, Houston, 2001*
5. *Spitzer D. W., Industrial Flow measurement, ISA press, 3rd Edition, 2005*

Course Outcomes:

After successfully completing this course, the student will be

1. Familiar with the different temperature measurement techniques used in process industries.
2. Familiar with various flow instrumentation used in industrial flow measurement.

3. Able to understand the working principle of different pressure transmitters and level sensors used in industries.
4. Able to identify or choose temperature, flow, pressure and level measuring device for specific process measurement.

ICMI13 – ESSENTIALS OF CONTROL ENGINEERING

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

This course is designed to expose students to
1. The fundamentals of feedback control system.
2. The variety of classical control schemes using simulation software.

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., & Bishop, R.H., Modern Control Systems, 13th edition, Prentice Hall, 2016.*
2. *Katsuhiko Ogata Modern Control Engineering, 5 edition, Pearson, 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, 8th edition, Wiley Publishers, India, 2003.*
3. *Ramakalyan A., Control Engineering- A comprehensive foundation, Vikas Publication, New Delhi, 2004.*
4. *Norman S. Nise, Control Systems Engineering, 4th edition, Wiley India publications, 2003.*

Course Outcomes:

1. The student learns the importance of feedback control system.
2. The student understands time domain and frequency domain techniques using simulation software.
3. The student is exposed to classical control design using simulation software.

ICMI14 – INDUSTRIAL AUTOMATION AND CONTROL

Course Type: Minor (MI) ***Pre-requisites:*** -
No. of Credits: 3

Course Learning Objectives:

This course is designed to expose students to understand the process automation concepts like Programmable logic controller and Distributed control system.

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 Profi bus – 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, 5th Edition, Prentice Hall Inc., New Jersey, 2002.*
2. *Lukcas M.P, Distributed Control Systems, Van Nostrand Reinhold Co., New York, 1986.*
3. *Frank D. Petruzella, Programmable Logic Controllers, 4th Edition, McGraw Hill, New York, 2010.*

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, 8th Edition, Prentice Hall, New Delhi, 2005.*
3. *Krishna Kant, Computer-based Industrial Control, 2nd edition, Prentice Hall, New Delhi, 2011.*

Course Outcomes:

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

1. Understand the popular process automation technologies.
2. Design and development of PLC ladder programming for simple process applications.
3. Understand the different security design approaches, Engineering and operator interface issues for designing Distributed control system.
4. Know the latest communication technologies like HART and Field bus protocol

ICLR10 – THERMODYNAMICS AND FLUID MECHANICS LABORATORY

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

Course Learning Objectives:

1. To understand the principles of thermal energy and its transformation to mechanical energy.
2. Thermodynamics - concepts and properties, first and second law
3. It provides a working knowledge of thermodynamics & 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 – Venturimeter 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, 7th edition, McGraw Hill, New York, 1997.*
2. *Ojha C.S.P., Berndtsson R., Chandramouli P.N., Fluid Mechanics and Machinery, Oxford University Press,2010.*

Course Outcomes:

1. An understanding of heat, work, internal energy, 1st and 2nd law of thermodynamics
2. An understanding of Dimensional Analysis, fluid statics and dynamics
3. An understanding of fluid mechanics fundamentals, including concepts of mass and momentum conservation.
4. An ability to apply the Bernoulli equation & control volume analysis to solve problems in fluid mechanics.

ICLR11 – CIRCUITS AND DIGITAL LABORATORY

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

Course Learning Objectives:

1. To understand the principles of thermal energy and its transformation to mechanical energy.
2. Thermodynamics - concepts and properties, first and second law
3. It provides a working knowledge of thermodynamics & fluid mechanics.

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. & Durbin, Engineering Circuit Analysis, McGraw Hill Publications, 8th edition, 2013.*
2. *Ramakalyan, A., Linear Circuits: Analysis & 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:

At the end of the course student will be

1. Familiar with electrical circuit laws and network theorem verifications.
2. Familiar with time response and frequency response of RL, RC and RLC circuits.
3. Able to design and verify sequential and combinational logic circuits.

ICLR12 – SENSORS AND TRANSDUCERS LABORATORY

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

Course Learning Objectives:

The aim of this lab is to fortify the students with an adequate work experience in the measurement of different quantities and also then expertise in handling the instruments involved.

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:

At the end of the course student will be able to

1. Design a signal conditioning circuits for transducers and test its characteristics.
2. Draw the specification of transducer for a given application.

ICLR13 – ANALOG SIGNAL PROCESSING LABORATORY

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

Course Learning Objectives:

Real word looks for system-level design skills in both analog and digital domains. The main focus of the lab is analog system design. It will cover the design and test of practical circuits based on op-amps and other ICs.
This lab course enables the students to study, design and implement various practical circuits. It also imparts a sound knowledge about the applications of Op-amp. The objective is to provide working practice in simulation tools & experiment test bench to learn the design and testing of various circuits

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 & 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 course, the student will understand the design and testing concepts of various practical circuits.

ICLR14 – INSTRUMENTATION LABORATORY

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

Course Learning Objectives:

The aim of this lab is to impart an adequate knowledge and expertise to handle equipment generally available in an industry.

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:

At the end of the course student will be able to understand and analyse Instrumentation systems and their applications to various industries.

ICLR15 – MICROPROCESSORS AND MICROCONTROLLERS LABORATORY

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

Course Learning Objectives:

The aim of this laboratory course is to make students:

1. To interface the microprocessor with external peripherals.
2. Familiar with ARM processor to learn how a program gets executed in a microprocessor/ microcontroller.
3. Fabricate a micro-controller circuit board using KiCAD open-source PCB design tool.
4. Program a micro-controller using a C language based compiler.

As a part of this laboratory course, the students will have to interface microprocessor with external peripherals.
The students have to practice the ARM processor programming in the LPC2148 kit.
Students have to fabricate a 8051-based hardware board and perform the microcontroller experiments.

List of Experiments:

1. Programming exercises to programmable peripheral interface.
2. Programming exercises using interrupts.
3. Programming exercises to use the timer.
4. Familiarization with 8051 micro-controller board and its assembler.
5. Programming exercises using 8051 micro-controller.
6. Basic I/O operations and ADC Interfacing using KEIL software.
7. Counting Pulses using Interrupt and Serial Data Transmission.
8. Interfacing 8051 with DAC.
9. Interfacing 8051 with stepper motor.
10. Real time clock and memory interfacing with 8051.
11. Programming exercise using ARM processor.

Reference Books:

1. *Ramesh Goankar, Microprocessor Architecture, Programming and applications with the 8085/8080A, 3rd Edition, Penram International Publishing house, 2002.*
2. *Kenneth J.Ayala, The 8051 Micro controller, Thomson Delmar Learning, 3rd Edition, 2004.*
3. *Andrew N. Sloss, Dominic Symes, and Chris Wright, ARM System Developer's Guide: Designing and Optimizing System Software, Morgan Kaufmann Publishers, 2004.*

Course Outcomes:

Upon completion of the lab course, Student can able to
1. Know the various functional blocks of microprocessor and microcontrollers.
2. Gain adequate knowledge in assembly language programming and C programming.
3. Interface the peripherals with microprocessor and microcontrollers.

ICLR16 – CONTROL ENGINEERING LABORATORY

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

Course Learning Objectives:

1. To provide knowledge on analysis and design of control system.
2. Students can apply 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.

Reference Books:

1. *Dorf, R.C., & 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:

1. Develop an ability to design control systems.
2. Students can design and implement controller designs to regulate and control various processes and systems.

ICLR17 – INDUSTRIAL AUTOMATION AND PROCESS CONTROL LABORATORY

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

Course Learning Objectives:

The course aims to give the students

1. Practical experience in PC based data acquisition, analysis and control of different process trainers.
2. To understand the industrial automation concept and programming techniques.

List of Experiments:

1. Identification of FOPDT and SOPDT process using time domain and frequency domain techniques.
2. Design of different PID controller for FOPDT and SOPDT process using different standard technique and evaluate qualitative & quantitative performance.
3. Study of Different Process trainers.
4. Design and Verification of Combinational & Sequential Circuits Using PLC.
5. Design of PID Controller for a Level Process/Temperature/Flow/Pressure process stations and evaluate servo/regulatory responses.
6. Study the effect of different PID Controller Parameters using real time process trainer.
7. Pressure to Current & 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 control value trainer.
12. Development of P&I design using Distributed control system (DCS).

Reference Books:

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

Course Outcomes:

After completing this course, the student can gain practical knowledge on Industrial automation concepts using PC, PLC and DCS techniques.

ICHO10 – DESIGN OF SENSORS AND TRANSDUCERS

Course Type: Honours (HO) ***Pre-requisites:*** ICPC11
No. of Credits: 3

Course Learning Objectives:

1. To provide fundamentals of various types of diaphragm design.
2. To equip design methodology for the design of strain gauge based load, torque, force and pressure measurement system.
3. To familiarize with design of capacitive and inductive transducer and its applications.
4. To furnish the design knowledge about accelerometer and gyroscope.
5. 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 – Design of convex diaphragms, semiconductor diaphragms and rectangular diaphragms – Design of corrugated diaphragms.

Design of strain gauge based load cells, torque sensors, force sensors and pressure sensors.

Design of capacitance based displacement, pressure and level sensors; Design of self and mutual inductance transducers for measurement of displacement and other parameters; Design of capacitive and inductive proximity sensors.

Accelerometer and Gyroscopic design and its applications. Design of Hall Effect sensors, Electromagnetic sensors, Magneto-elastic sensors.

Introduction to chemical Sensors, characteristics. Design of direct and complex chemical sensors.

Text Books:

1. *Karl Hoffmann, An introduction to stress analysis and transducer design using strain gauges, HBM.*
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. *Authors: Fraden, Jacob, Handbook of Modern Sensors: Physics, Designs, and Applications, 3rd Editions, Springer.*

Reference Books:

1. *Richard S. Figliola, Donald E. Beasley, Theory and Design for Mechanical Measurements, 6th Edition, John Wiley & Sons, Inc.*
2. *Authors: Fraden, Jacob, Handbook of Modern Sensors: Physics, Designs, and Applications, 3rd Editions, Springer*

3. *Alexander D. Khazan, Transducers and Their Elements: Design and Application, PTR Prentice Hall, 1994*
4. *Peter H. Sydenham, Richard Thorn, Handbook of Measuring System Design, Wiley*

Course Outcomes:

1. Students will be in a position to select and design diaphragm for different sensing applications.
2. Students will be able to design strain gauge based torque, force, load and pressure measurement systems.
3. Students can design capacitance/ inductance transducers for the measurement of displacement, pressure and level.
4. Students will gain knowledge in design of accelerometer and gyroscope.
5. Students will know about different chemical sensors and their design criteria.

ICHO11 - INSTRUMENTATION SYSTEM DESIGN

Course Type: Honours (HO) ***Pre-requisites:*** ICPC17, ICPC22
No. of Credits: 3

Course Learning Objectives:

To obtain adequate knowledge in design of various signal conditioning circuits, instrumentation systems, controller and control valve.

Course Content:

Flow and Temperature:
Orifice meter - design of orifice for given flow condition - design of rotameter -design of RTD measuring circuit - design of cold junction compensation circuit for thermocouple using RTD - Transmitters – zero and span adjustment in D/P transmitters and temperature transmitters.

Pressure and Level:
Bourdon gauges - factors affecting sensitivity - design of Bourdon tube -design of Air purge system for level measurement.

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.

Pumps:
Types of pumps - pump performance - pipe work calculation - characteristics of different pumps - pump operation - maintenance - instruments used in pumping practice - pump noise and vibration - selection of pumps. Electronic P+I+D controllers - design - adjustment of setpoint, bias and controller settings.

Microcontroller Based Design:
Design of logic circuits for alarm and annunciator circuits, interlocks - design of microcontroller based system for data acquisition - design of microprocessor based P+I+D controller.

Text Books:

1. *Anderson N.A., Instrumentation for Process Measurment and Control, 3/e,Routledge, 1997.*
2. *Considine D.M., Process Instruments and Controls Handbook, 5/e McGraw-Hill., 2009.*

Reference Books:

1. *Johnson C.D., Process Control Instrumentation Technology, 8/e Prentice Hall of India, 2009.*

Course Outcomes:

Ability to understand and analyze Instrumentation systems and their applications to various industries.

ICHO12 - MICRO SYSTEM DESIGN

Course Type: Honours (HO) ***Pre-requisites:*** ICPE12
No. of Credits: 3

Course Learning 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 and micro accelerometer.
5. To provide knowledge 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,2001.*

Reference Books:

1. *Minhang Bao., Analysis and Design Principles of MEMS Devices, Elsevier, 2005.*
2. *M. Elwenspoek, R. Wiegerink, Mechanical Microsensors, Springer, Berlin, 2001.*
3. *Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill, Boston, 2002 (ISBN 0-07-23939 1-2)*

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.
4. Design micro pressure and micro accelerometer.
5. Understand sensor integration and packaging techniques.

ICHO13 – ADVANCED CONTROL SYSTEM DESIGN

Course Type: Honours (HO) ***Pre-requisites:*** ICPC21, ICPC24
No. of Credits: 3

Course Learning Objectives:

In this course concepts and techniques of linear and nonlinear control system analysis and synthesis will be studied in the modern control (state space) framework.

The theory as well as the illustrative will be quite generic and hence this course is expected to be useful to the students from other engineering disciplines too.

Course Content

Introduction, Review of Classical Control, Examples of Dynamical Systems – Robotics, Aerospace Applications.

Review of Matrix algebra and numerical methods.

Time response, Stability, Controllability, Observability, Controller design and Observer design,

Linear control applications in Robotics and Aerospace.

Lyapunov theory, Nonlinear control synthesis methods, Nonlinear observer and Kalman filter design.

Optimal control design, Intelligent control design.

Text Books:

1. *Roland Burns, Advanced Control Engineering, Butterworth-Heinemann, 2001*
2. *Goodwin, Graebe, Salgado, Control System Design, Prentice Hall. 2001.*
3. *N. S. Nise: Control Systems Engineering, 4th Ed., Wiley, 2004.*
4. *B. Friedland: Control System Design, McGraw Hill, 1986.*

Reference Books:

1. *Khalil, Nonlinear Systems, Prentice-Hall, 2nd+ Ed. 1996.*
2. *E. Bryson and Y-C Ho: Applied Optimal Control, Taylor and Francis, 1975.*

Course Outcomes:

Upon completing the course, the student would be able to

1. Develop mathematical models and how they govern the fundamentals in control systems.
2. Design pole-assignment controllers, observers, and the specific design procedures.
3. Design nonlinear controllers using Lyapunov theory.
4. Design optimal, robust, and intelligent controllers for more complex system.

ICHO14 - ADVANCED PROCESS CONTROL

Course Type: Honours (HO) ***Pre-requisites:*** ICPC21, ICPC25
No. of Credits: 3

Course Learning Objectives:

The aim of this course is to familiarize the student in

1. System identification and parameter estimation
2. Various interaction measure
3. Multi-objective optimization
4. Multivariable control
5. robust control , plant wide control

Course Content:

Development of Black-box Models

Stability Analysis, Interaction Analysis and Multi-loop Control

Controller Tuning Methods using Multi-Objective Optimization, Model predictive control (MPC)

Multivariable control using state space concepts

Robust control – robust stability – introduction to plant wide control

Text Books:

1. *Astrom, K. J., and B. Wittenmark, Computer Controlled Systems, Prentice Hall India (1994).*
2. *Franklin, G. F., Powell, J. D., and M. L. Workman, Digital Control Systems, Addison Wesley, 1990.*
3. *D. E. Seborg, T. F. Edgar, D. A. Mellichamp, Process Dynamics and Control, Wiley, 2003.*

Reference Books:

1. *Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, Control System Design, Prentice Hall, 2000.*
2. *Gade Pandu Rangaiah Prof Adrian Bonilla-Petriciolet, Multi-Objective Optimization in Chemical Engineering: Developments and Applications, Wiley, 2013.*

Course Outcomes:

On completion of this course, the student will understand

1. LS & RLS method
2. Various interaction indices,
3. Pareto optimality

4. Centralized control
5. kharitonov theorem and small gain theorem

ICHO15 – OPTIMAL AND ROBUST CONTROL

Course Type: Honours (HO) ***Pre-requisites:*** ICPC21, ICPC24
No. of Credits: 3

Course Learning Objectives:

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 & 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. *K. Zhou, J. C. Doyle and K. Glover, Robust & Optimal Control, Prentice Hall, 1996.*
2. *B. D. O. Anderson and J. B. Moore, Optimal Control: Linear Quadratic Methods, Prentice Hall, 1989.*
3. *A. E. Bryson Jr. and Y. C. Ho, Applied Optimal Control, Taylor and Francis, 1975.*

Reference Books:

1. *J. C. Doyle, B. Francis and A. Tannenbaum, Feedback Control Theory, Macmillan, 1990.*
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 – ELECTRONICS FOR SENSOR DESIGN

Course Type: Honours (HO) ***Pre-requisites:*** ICPC14, ICPC18, ICPC20
No. of Credits: 3

Course Learning Objectives:

1. To design signal conditioning circuits for resistive and capacitive transducers to obtain improved characteristics.
2. To impart knowledge about electronic conditioning circuits for temperature measuring transducers.
3. To convey the principle and design of transmitters with industrial standard.
4. To impart the knowledge of data acquisition system design.
5. To provide knowledge about the use of artificial intelligence technique for enhancing sensor characteristics**.**

Course Content:

Design of basic and advanced analog electronic circuits for resistive and capacitive transducers. Conditioning circuits for linearization – sensitivity improvement – offset and span adjustments.

Review of Thermocouple, RTD and thermistor characteristics – Review of basic analog electronic conditioning circuits. Importance of linearity – Hardware and software methods for linearization, Importance of sensitivity – design aspects for sensitivity improvement. EMI and EMC design aspects.

Review of transmitters – design of two wire and four wire transmitters using analog electronic circuits and IC's.

Introduction to data acquisition system, issues related to interfacing of static and dynamic sensors. Design of data acquisition for a given measurement application (Theory and practical).

Introduction to Fuzzy logic and neural networks. Use of Fuzzy logic and neural networks for sensor linearization and improvement of other characteristics.

Text Books:

1. *Dan Sheingold, Editor, Transducer Interfacing Handbook, Analog Devices, Inc., 1980.*
2. *William C. Dunn, Introduction to Instrumentation, Sensors, and Process Control, Artech House.*
3. *Jacob Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications, Springer*
4. *H.R. Taylor, Data Acquisition for Sensor Systems, 2010 – Springer.*
5. *Manabendra Bhuyan, Intelligent Instrumentation: Principles and Applications, CRC Press Taylor & Francis Group.*

Reference Books:

1. *Ramon Pallás Areny, John G. Webster, "Sensors and Signal Conditioning", 2nd edition, John Wiley and Sons, 2000.*

2. *Thomas L. Floyd, David Buchla, Fundamentals of analog circuits, 2002- Prentice Hall.*
3. *Ernest O. Doebelin; "Measurement System Application and Design "; Mc-Graw Hill; 5th Edition.*

Course Outcomes:

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

1. Design signal conditioning circuits for resistive and capacitive transducers
2. Understand the procedure to design conditioning circuits for temperature measuring transducers.
3. Design the transmitters for sensor interface.
4. Understand the design methods of data acquisition system.
5. Use artificial intelligence techniques for improving sensor characteristics.

ICHO17 – SYSTEM ON CHIP

Course Type: Honours (HO) ***Pre-requisites:*** ICPC18
No. of Credits: 3

Course Learning Objectives:

With technological advances that allow us to integrate complete multiprocessor systems on a single die, Systems-on-Chip (SoCs) are at the core of most embedded computing and consumer devices, such as cell phones, media players and automotive, aerospace or medical electronics. This course will provide an understanding of the concepts, issues, and process of designing highly integrated SoCs following systematic hardware/software co-design & co-verification Principles using state of the art synthesis and verification tools and design flows.

Course Content:

SOC Design:
Hardware System Structure, Software Structure, Current SOC Design Flow, the Impact of Semiconductor Economics, Six Major Issues in SOC Design;

A New Look at SOC Design:
Accelerating Processors for Traditional Software Tasks, System Design with Multiple Processors, New Essentials of SOC Design Methodology, Addressing the Six Problems.

System-Level Design of Complex SOCs:
Complex SOC System Architecture Opportunities, Major Decisions in Processor-Centric SOC Organization, Communication Design = Software Mode + Hardware Interconnect, Hardware Interconnect Mechanisms, Performance-Driven Communication Design, The SOC Design Flow , Non-Processor Building Blocks in Complex SOC, Implications of Processor-Centric SOC Architecture.

Configurable Processors: A Software View:
Processor Hardware/Software Cogeneration, The Process of Instruction Definition and Application Tuning, The Basics of Instruction Extension, The Programmer's Model, Processor Performance Factors, Example: Tuning a Large Task, Memory-System Tuning, Long Instruction Words.

Configurable Processors: A Hardware View:
Application Acceleration: A Common Problem, Introduction to Pipelines and Processors, Hardware Blocks to Processors, Moving from Hardwired Engines to Processors, Designing the Processor Interface, Novel Roles for Processors in Hardware Replacement, Processors, Hardware Implementation, and Verification Flow

Text Books:

1. *C. Rowen, Engineering the Complex SOC: Fast, Flexible Design with Configurable Processors, Prentice Hall, 2004.*

Reference Books:

1. *R. Zurawski (Editor), Embedded Systems Handbook, CRC Press.*
2. *D. Gajski, S. Abdi, A. Gerstlauer, G. Schirner, Embedded System Design: Modeling, Synthesis, Verification, Springer, 2009.*
3. *P. Marwedel, Embedded System Design, Springer, 2003.*
4. *G. De Micheli, Synthesis and Optimization of Digital Circuits, McGraw-Hill, 1994.*
5. *T. Noergaard, Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers, Newnes.*

Course Outcomes:

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

1. Understand hardware, software, and interface synthesis with emphasis on issues in interface design.
2. Describe examples of applications and systems developed using a co-design approach.
3. Model and specify embedded systems at high levels of abstraction.
4. Analyse the functional and non-functional performance of the system early in the design process to support design decisions.
5. Use co-simulation to validate system functionality.