B. Tech. Degree

In

INSTRUMENTATION AND CONTROL ENGINEERING

SYLLABUS FOR

FLEXIBLE CURRICULUM

(For students admitted in 2015-16, 2016-17 & 2017-18)

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.

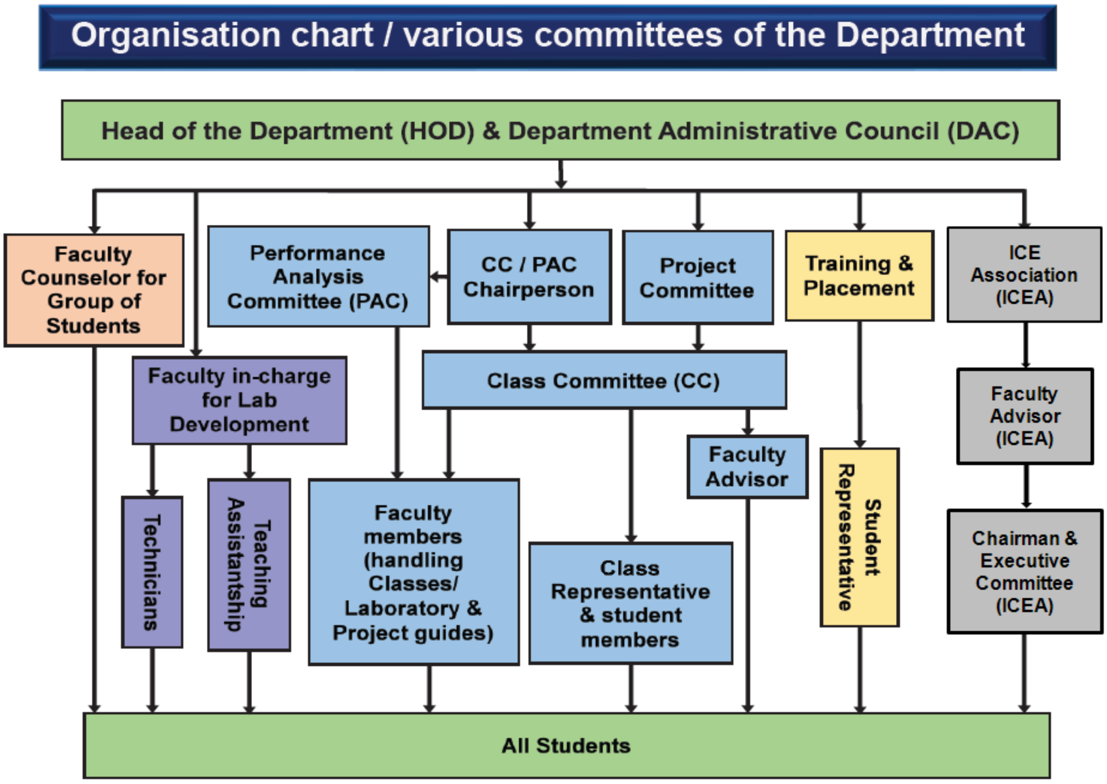
DEPARTMENT VISION

- 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**	**Pre-Req**	**Credits**
1.	ICPC10	Engineering Mechanics	---	3
2.	ICPC11	Sensors and Transducers	---	3
3.	ICPC12	Material 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	ICPC15	3
12.	ICPC21	Control Systems – I	---	4
13.	ICPC22	Instrumentation Practices in Industries	ICPC17	3
14.	ICPC23	Principles of Communication Systems	---	3
15.	ICPC24	Control Systems – II	ICPC21	3
16.	ICPC25	Process Control	ICPC21	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 Systems	-	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 ELECTIVE COURSES				
S.No.	**Course Code**	**Course Title**	**Pre-Req.**	**Credits**
1.	ICPE10	Optical Instrumentation	-	3
2.	ICPE11	Medical Instrumentation	-	3
3.	ICPE12	Micro Electro Mechanical Systems	ICPC11	3
4.	ICPE13	Automotive Instrumentation	ICPC11 ICPC17	3
5.	ICPE14	Instrumentation and Control for Power Plant	-	3
6.	ICPE15	Instrumentation and Control for Petrochemical Industries	-	3
7.	ICPE16	Instrumentation and Control for Paper Industries	-	3
8.	ICPE17	Instrumentation for Agricultural and Food Processing Industries	-	3
9.	ICPE18	Introduction to Chemical Processes	-	3
10.	ICPE19	Measurement Data Analysis	-	3
11.	ICPE20	Building Automation	-	3
12.	ICPE21	Digital Control Systems	ICPC24	3
13.	ICPE22	Neural Networks and Fuzzy Logic	-	3
14.	ICPE23	Non Linear Control	ICPC24	3

15.	ICPE24	System Identification and Adaptive Control	ICPC24	3
16.	ICPE25	Fault Detection and Diagnosis	ICPC21	3
17.	ICPE26	Computational Techniques in Control Engineering	ICPC24	3
18.	ICPE27	Process Modelling and Optimization	ICPE18	3
19.	ICPE28	Control System Components	-	3
20.	ICPE29	Network Control Systems	-	3
21.	ICPE30	Digital Signal Processing	ICPC16	3
22.	ICPE31	Power Electronics	-	3
23.	ICPE32	Real-Time Embedded Systems	ICPC20	3
24.	ICPE33	Smart and Wireless Instrumentation	-	3
25.	ICPE34	Digital Image Processing	-	3
26.	ICPE35	Multi Sensor Data Fusion	ICPC24	3
27.	ICPE36	Medical Imaging Systems	ICPE34	3
28.	ICPE37	Industrial Data Communication	-	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	-	3
33.	ICPE42	Software Design Tools for Sensing and Control	ICPC11 ICPC21	3
34.	ICPE43	Industrial Electric Drives	ICPE31	3
35.	ICPE44	Piping and Instrumentation Diagrams	ICPE18	3
36.	ICPE45	Robotics	ICPC21 ICPC24	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**	**Pre-Req**	**Credits**
1.	ICOE10	Building Automation	-	3
2.	ICOE11	Project Engineering and Management	-	3
3.	ICOE12	Medical Instrumentation	-	3
4.	ICOE13	Micro Electro Mechanical Systems	-	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 Systems	-	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**	**Pre-Req**	**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**	**Pre-Req**	**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**	**Pre-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	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

Programme Core (PC) Courses

ICPC10 - ENGINEERING MECHANICS

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

Course 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 WC, Mechanical Science, Wiley-Blackwell Publishing, 3rd Edition. 2006.*
2. *Shames Irving H., Engineering Mechanics: Statics and Dynamics, Pearson Education, 4th Edition, 2006.*
3. *Beer, Ferdinand P., Johnston, E. Russel, Mazurek, David F., Cornwell, Phillip J.and Brian Self, Vector Mechanics for Engineers: Statics and Dynamics, McGraw- Hill Education (India), 11th Edition. 2015.*

Course outcomes:

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

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

ICPC11 - SENSORS AND TRANSDUCERS

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

Course Objectives:

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

Course Content:

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

Resistive transducers: Potentiometers, metal and semiconductor strain gauges and signal conditioning circuits, strain gauge applications: Load and torque measurement, Digital displacement sensors.

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.

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

Text Books:

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

On completion of this course, the students will be,

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

ICPC12 - MATERIAL SCIENCE

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

Course Objectives:

1. To introduce the basic principles of Material Science and apply those principles to engineering applications.
2. To teach the structure, properties, advantages and limitations of engineering materials.
3. To introduce the structure-property correlations in materials to develop materials for demanding 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 under 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 structure 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, John Wiley & Sons Inc., New York, 6th Edition, 2002.*
2. *Raghavan V. Materials Science and Engineering – A first course, Prentice Hall, New Delhi, 5th Edition, 2004.*

3. *Van Vlack, LH, Elements of Materials Science and Engineering, Addison – Wesley Singapore, 6th Edition, 1989.*

Reference Books:

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

Course outcomes:

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

1. identify the structure and understand the electrical, magnetic and optical properties of different materials.
2. interpret the phase diagrams and apprehend the phase transformations.
3. assess the mechanical properties of the materials using the associated testing methods.
4. select and develop materials for specific instrumentation applications.

ICPC13 - THERMODYNAMICS AND FLUID MECHANICS

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

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

1. *Zemansky, Heat and Thermodynamics, McGraw Hill, New York, 7th Edition, 1997.*
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, McGraw Hill, New York, 9th Edition, 1997.*

Reference Books:

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

Course outcomes:

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

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

ICPC14 - CIRCUIT THEORY

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

Course Objectives:

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

Course Content:

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

Analysis of Resistive Circuits energized by dc voltages and currents – Source Transformations, Nodal and Mesh Analysis, Principle of Superposition, Network Theorems (Thevenin's and Norton's, 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:

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

1. analyze and solve the DC and AC circuits using network theorems and mathematical tools.
2. apply the knowledge of the time domain and frequency domain characteristics of electrical circuits for design.
3. design and synthesis two port networks.

ICPC15 - DIGITAL ELECTRONICS

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

Course Objectives:

The subject aims to provide the student with

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

Course Content:

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

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

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

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

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

Text Books:

1. *M.M. Mano, Digital Logic and Computer Design, Pearson, 4th Edition, 2014.*
2. *J.P. Uyemura, A First Course in Digital Systems Design: An Integrated Approach, Nelson Engineering, 1999.*
3. *W. H. Gothmann, Digital Electronics - An Introduction to Theory and Practice, Prentice Hall of India, 2000*

Reference Books:

1. *J.M. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall of India, 2nd Edition, 2003.*
2. *N.H.E. Weste, and K. Eshraghian, Principles of CMOS VLSI Design: A Systems Perspective, Pearson Education Inc., (Asia), 3rd Edition, 2005.*
3. *S. Brown and Z Vranesic, Fundamentals of Logic Design with VHDL Design, Tata McGraw-Hill , 2000*
4. *V. P. Nelson, H.T. Nagle, E.D. Caroll and J.D. Irwin, Digital Logic Circuit Analysis and Design, Prentice Hall International, 1995*

Course outcomes:

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

1. understand how digital and logic computing can be arrived at from the digital number systems and codes.
2. build the digital and logic (computing) circuits from the fundamental semiconductor electronics.
3. apply the knowledge on basic logics and techniques to analyze and design digital electronic circuits.
4. develop expertise to design and implement digital circuits to be applicable for signal measurement and processing.

ICPC16 - SIGNALS AND SYSTEMS

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

Course Objectives:

1. This course introduces the student to identify and represent the type of signals and systems.
2. The students are introduced to the mathematical tools available to analyze the signals and systems.
3. A section of the course introduces about the random phenomena in the real world and the mathematical models.
4. To introduce about pseudo-random signals in identifying systems.

Course Content:

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

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

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

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

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

Text Books:

1. *Gabel R.A. and Robert R.A., Signals and Linear Systems, John Wiley and Sons, 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.*
4. *B.P. Lathi, Principles of Linear Systems and Signals, Oxford University Press, 2nd 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, 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:

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

1. identify the types of signals and systems with general understanding of continuous time and discrete time signals and systems.
2. analyze signals and systems using transforms.
3. 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 Objectives:

1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
3. To make the students knowledgeable in the design, installation and trouble shooting of process instruments.

Course Content:

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

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

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

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

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

Text Books:

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

Reference Books:

1. *B.E.Noltingk, Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.*
2. *Douglas M. Considine, Process / Industrial Instruments & Controls Handbook, McGraw Hill, Singapore, 5th Edition, 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:

On completion of this course, the students will be,

1. familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
2. able to select and make measurements of temperature, flow, pressure and level in any process industry.
3. able to identify or choose temperature, flow, pressure and level measuring device for specific process.

ICPC18 - ANALOG SIGNAL PROCESSING

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

Course Objectives:

This course emphasizes intuitive understanding and practical implementations of the theoretical concepts of amplifiers, filters and other circuits which are essential for signal conditioning.

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. Universal Filters and their application

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

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

Case studies: bridge linearization, PLL design using divider and multipliers, regulator design with low voltage dropout, 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.*
3. *James M. Fiore, Op Amps and Linear Integrated Circuits – Concepts and Applications, Cengage Learning Pvt, Ltd, 3rd Edition, 2016.*

Course outcomes:

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

1. understand the implications of the properties of systems and signals.
2. design and simulate various analog signal conditioning circuits.
3. implement various analog signal conditioning circuits in real time.
4. trouble shoot analog signal conditioning circuits.

ICPC19 - ELECTRICAL AND ELECTRONIC MEASUREMENTS

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

Course Objectives:

1. To give an overview of current, voltage and power measuring electrical, electronics and digital instruments.
2. To expose the students to the design of bridges for the measurement of resistance, capacitance and inductance.
3. To give an overview of test and measuring instruments.

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.

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

On completion of this course, the students will be,

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

ICPC20 - MICROPROCESSORS AND MICROCONTROLLERS

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

Course Objectives:

1. To introduce the architecture of 8, 16 and 32 bit microprocessor and microcontroller.
2. To impart microcontroller programming skills in students.
3. To familiarize the students with data transfer and interrupt services.

Course Content:

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

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

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

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

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

Text Books:

1. *Douglas V. Hall, Microprocessors and Interfacing-Programming and Hardware, Mc Graw Hill, 2nd Edition, 1999.*
2. *Kenneth J.Ayala, The 8051 Micro controller, Thomson Delmar Learning, 3rd Edition, 2004.*
3. *John H Davies, MSP430 Microcontroller Basics, Newnes, 1st Edition, 2010.*

Reference Books:

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

Course outcomes:

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

1. understand the various functional blocks of microprocessor and microcontrollers.
2. understand and write an assembly language program.
3. interface the peripherals with microprocessors and microcontrollers.

ICPC21 - CONTROL SYSTEMS - I

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

Course Objectives:

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

Course Content:

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

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

The Root Locus Method, Feedback Control System Analysis & 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, Prentice Hall, 13th edition, 2016.*
2. *Katsuhiko Ogata, "Modern Control Engineering", PHI Learning Private Ltd, 5th Edition, 2010.*
3. *Franklin, G.F., David Powell, J., Emami-Naeini, A., Feedback Control of Dynamic Systems, Prentice Hall, 7th Edition, 2014.*

Reference Books:

1. *Nise, N.S., Control Systems Engineering, Wiley, 7th Edition, 2015.*
2. *John J.D., Azzo Constantine, H. and Houpis Sttuart, N Sheldon, "Linear Control System Analysis and Design with MATLAB", CRC Taylor& Francis Reprint 2009.*
3. *Dutton, K., Thompson, S., Barralough, B., The Art of Control Engineering, Prentice Hall, 1997.*

Course outcomes:

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

1. generate mathematical models of dynamic control system by applying differential equations.
2. analyze and characterize the behavior of a control system in terms of different system and performance parameters.
3. compute and assess system stability.
4. evaluate and analyses system performance using frequency and transient response analysis.
5. design and simulate control systems (linear feedback control systems, PID controller, and multivariable control systems), using control software, to achieve required stability, performance and robustness.
6. critically analyses and outline the dynamic response of closed loop systems.

ICPC22 - INSTRUMENTATION PRACTICES IN INDUSTRIES

Course type: Programme Core (PC) ***Pre-requisites:*** ICPC17
No. of Credits: 3

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

1. *Noltingk B.E., Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.*
2. *Liptak B.G, Process Measurement and Analysis, Chilton Book Company, Radnor, Pennsylvania, 4th Edition, 2003.*
3. *Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I &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:

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

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

ICPC23 - PRINCIPLES OF COMMUNICATION SYSTEMS

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

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

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

Reference Books:

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

Course outcomes:

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

1. explain the basic concepts of communication systems.
2. establish understanding of various analog and digital modulation techniques and demodulation techniques.
3. describe different types of noise and calculate the noise equivalent bandwidth and noise figure of a two-port network.

ICPC24 - CONTROL SYSTEMS – II

Course type: Programme Core (PC) ***Pre-requisites:*** ICPC21
No. of Credits: 3

Course Objectives:

1. To introduce about the system states and state space; System representation in states space form.
2. To teach the advanced methods and techniques of linear system analysis and Lyapunov stability.
3. To impart knowledge in the control techniques for design of a larger scale of systems.

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. One detailed case study of modern control theory.

Text Books:

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

Reference Books:

1. *John J.D., Azzo Constantine, H. and Houpis Sttuart, N Sheldon, Linear Control System Analysis and Design with MATLAB, CRC Taylor& Francis Reprint 2009.*
2. *I.J. Nagrath and M. Gopal, Control Systems Engineering, New Age International Publishers, 4th Edition, 2012.*

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

Course outcomes:

On completion of this course, the students will be,

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

ICPC25 - PROCESS CONTROL

Course type: Programme Core (PC) ***Pre-requisites:*** ICPC21
No. of Credits: 4

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

1. *G.Stephanopoulos, Chemical Process Control-An Introduction to Theory and Practice Prentice Hall of India, New Delhi, 3rd Edition, 2008.*

2. *D.R. Coughanowr, Steven E LeBlanc, Process Systems Analysis and Control, McGraw Hill, Singapore, 3rd Edition, 2009.*
3. *B.W. Bequette, Process Control Modeling, Design and Simulation, Prentice Hall of India, New Delhi, 2004.*

Reference Books:

1. *C.A.Smith and A.B Corripio., Principles and Practice of Automatic Process Control, John Wiley and Sons, New York, 3rd Edition 2005.*
2. *Paul W.Murril, Fundamentals of Process Control Theory, ISA press, New York, 3rd Edition, 2000.*
3. *Bela G. Liptak, Instrument Engineers' Handbook, Volume II: Process Control and Optimization, CRC Press, 4th Edition, 2005*

Course outcomes:

On completion of this course, the students will be,

1. familiar with process modelling.
2. able to select and design PID controller for any process, adopting suitable tuning methodology.
3. able to comprehend about the advanced process control strategies.

ICPC26 - PRODUCT DESIGN AND DEVELOPMENT (THEORY)

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

Course Objectives:

1. The aim of this course is to inculcate into the student the spirit of innovation and entrepreneurship. This is achieved in this course by making the students to develop a marketable product on their own as a group. At the end of this 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:***
No. of Credits: 2

Course Objectives:

1. The aim of this course is to inculcate into the student the spirit of innovation and entrepreneurship. This is achieved in this course by making the students to develop a marketable product on their own as a group. At the end of this 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:

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

1. make market surveys for new product development
2. plan the entire cycle of new product design and development.
3. fabricate prototypes of new products and test them.

ICPC28 - ANALYTICAL INSTRUMENTATION

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

Course Objectives:

1. To teach the students about the analysis of materials which is an important requirement of process control and quality control in industry.
2. To expose the students to principles of various analytical methods.
3. The impart knowledge on 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, McGraw Hill, Singapore, 5th Edition, 1992.*
3. *Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.*

Reference Books:

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

Course outcomes:

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

1. appreciate the relevance of material sampling and analysis in process control and quality control in industry.
2. understand the physical principles behind the various widely used analytical methods in the industry.
3. select an appropriate analytical instrument for an industrial requirement.

ICPC29 - LOGIC AND DISTRIBUTED CONTROL SYSTEMS

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

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

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

Reference Books:

1. *Deshpande P.B and Ash R.H, Elements of Process Control Applications, ISA Press, New York, 1995.*

2. *Curtis D. Johnson, Process Control Instrumentation Technology, Pearson New International, 8th Edition, 2013.*
3. *Krishna Kant, Computer-based Industrial Control, Prentice Hall, New Delhi, 2nd Edition, 2011.*

Course outcomes:

On completion of this course, the students will be,

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

Programme Elective (PE) Courses

ICPE10 - OPTICAL INSTRUMENTATION

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

Course Objectives:

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

Course Content:

Introduction: Characteristics of optical radiation, luminescence.

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

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

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

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

Text Books:

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

Reference Books:

1. *Wilson and Hawkes, Opto Electronics - An Introduction, Prentice Hall, New Delhi, 3rd Edition, 2003.*

2. *Bhattacharya P, Semiconductor Optoelectronics, Prentice Hall, New Delhi, 2nd Edition, 2002.*
3. *Culshaw B. and Dakin J.(Eds.), Optical Fibre Sensors Vol I, II and III, Artech House, 1989.*
4. *Fukuda, Optical Semiconductor Devices, John Wiley, 1st Edition, 2005.*
5. *Kasap, Optoelectronics and Photonics: Principles and practices, Pearson Education, 2nd Edition 2012.*

Course Outcomes:

On completion of the course the students will be,

1. familiar with the fundamental principles of various types of optical sources, characteristics and its applications.
2. able to understood the operation of different types of optical detectors and its limitations in industrial use.
3. knowledgeable on fiber-optical components and systems and its industrial applications.

ICPE11 - MEDICAL INSTRUMENTATION

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

Course Objectives:

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

1. To educate the students on the different medical instruments.
2. To familiarise the students with the analysis and design of instruments to measure bio signals like ECG, EEG, EMG, etc.
3. To introduce about the applications of biomedical instrumentation.

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, 2nd Edition, 2001.*
2. *Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology, Cbs Publishers & Distributors, Prentice Hall, 4th Edition, 2000.*

Reference Books:

1. *L.A.Geddes and L.E.Baker, Principles of Applied Biomedical Instrumentation, John Wiley, New York, 3rd Edition, 2009.*
2. *R.S.Kandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill education, New Delhi, 3rd edition, 2014.*

Course Outcomes:

On completion of this course the students will be,

1. able to understand, design and evaluate systems and devices that can measure, test and/or acquire biological information from the human body.
2. familiar with patient monitoring equipment used in hospitals and in telemedicine.
3. familiar with various imaging techniques used for diagnosis.

ICPE12 - MICRO ELECTRO MECHANICAL SYSTEMS

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

Course Objectives:

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 provide knowledge in the design concepts of micro sensors and micro actuators.
4. To provide 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, CRC Press, 2nd Edition, 2002.*
3. *Julian W. Gardner and Vijay K. Varadan, Microsensors, MEMS, and Smart Devices, John Wiley & Sons Ltd, 1st Edition, reprinted 2007.*

Reference Books:

1. *Elwenspoek, Miko, Wiegerink, R, Mechanical Microsensors, Springer*-Verlag Berlin Heidelberg GmbH*, 1st Edition, 2001.*
2. *Simon M. Sze, Semiconductor Sensors, John Wiley & Sons. Inc, 1st Edition, 1994.*
3. *Chang Liu, Foundations of MEMS, Pearson Educational limited, 2nd Edition, 2011.*

Course Outcomes:

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

1. understand the fundamental principles behind the working of micro devices/ systems and their applications.
2. gain a fundamental understanding of standard micro fabrication techniques.
3. apply knowledge of micro fabrication 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 Objectives:

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

Course Content:

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, Head-Up Display (HUD), 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, Butterworth-Heinemann publications, 7th Edition, 2012.*

Reference Books:

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

Course Outcomes:

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

1. identify the automotive system and its components.
2. attain knowledge of various sensors and conditioning circuit used in automotive systems.
3. gain knowledge about various control strategies, the electronics and software used in automotive application.

ICPE14 - INSTRUMENTATION AND CONTROL FOR POWER PLANT

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

Course Objectives:

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

Course Content:

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

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

Controls in boiler: Problems associated with control of multiple pulverizers. Draught plant: Introduction, natural draught, forced draught, induced draught, balanced draught, power requirements for draught systems. Fan drives and control, control of air flow. Combustion control: Fuel/Air ratio, oxygen, CO and CO_2 trimming, combustion efficiency, excess air, parallel and cross limited combustion control, control of large systems.

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

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

Text Books:

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

Reference Books:

1. *Elonka, S.M.and Kohal A.L, Standard Boiler Operations, McGraw-Hill, New Delhi, 1994*.
2. *Philip Kiameh, Power Plant Instrumentation and Controls, McGraw-Hill Professional, 2014.*

Course Outcomes:

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

1. various power generation processes.
2. important parameters to be monitored and controlled in a thermal power plant.
3. major control systems involved in the thermal power plant and nuclear power plants.

ICPE15 - INSTRUMENTATION AND CONTROL FOR PETROCHEMICAL INDUSTRIES

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

Course Objectives:

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

Course Content:

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

P & 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, CRC PRESS, 4th Edition, 2003.*
2. *Austin G.T.Shreeves, Chemical Process Industries, McGraw Hill International student edition, singapore, 1985.*

Course Outcomes:

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

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

ICPE16 - INSTRUMENTATION AND CONTROL FOR PAPER INDUSTRIES

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

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

1. *John R. Lavigne, An introduction to paper industry Instrumentation, Miller Freeman Publications, California, 1977.*
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,* Backbeat Books *, California, 1979.*

Reference Books:

1. *James P. Casey, Pulp & Paper: Chemistry and Chemical Technology, John Wiley & Sons, New York, 3rd Edition, 1983.*
2. *Sankaranayanan P.E, Pulp and Paper Industries–Technology & Instrumentation, Kothari's Deskbook series, 1995.*
3. *Liptak B.G, Instrument Engineers Handbook, volume 2: Process Control, CRC press, London, 4th Edition, 2005.*

Course Outcomes:

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

1. appreciate the need of instrumentation and control in paper making.
2. understand the instrumentation and control used in paper and pulp industry.
3. suggest and analyse new instruments and control options in paper and pulp industry.

ICPE17 - INSTRUMENTATION FOR AGRICULTURAL AND FOOD PROCESSING INDUSTRIES

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

Course Objectives:

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

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

Reference Books:

1. *Mcmillan G..K., Considine D. M .,Process/Industrial Instruments and Controls Handbook, McGraw Hill International, 5th edition,1999.*
2. *Liptak B. G., Instrument Engineers Handbook, Process Measurement Volume I and Process Control Volume II, CRC press, 4th Edition,2005.*
3. *Hall C. W., Olsen W. C.,The literature of Agriculture Engineering, Cornell University Press, 1992.*
4. *Sahu J. K., Fundamentals of Food Process Engineering, Alpha Science Intl Ltd, 2016.*

Course Outcomes:

On completion of this course, the students will be,

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

ICPE18 – INTRODUCTION TO CHEMICAL PROCESSES

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

Course Objectives:

1. To expose the student to the broad spectrum of operations in the chemical engineering field.
2. To impart concepts of unit operations, heat mass and momentum transfer.
3. To introduce mass transfer concept and basics of fluid flow equipments.

Course Content:

Concept of unit operations:

Unit processes and equipment's, comminution, mixing and separations. Mechanical operations Principles and equipment. Concepts of equilibrium and rate.

Heat mass and momentum transfer:

Entropy balance. Material balance, Heat transfer concepts and equipment, Heat exchangers, furnaces and evaporators. Refrigeration process.

Mass transfer concept of staged processes:

Process principles of distillation, absorption. Adsorption, humidification, drying and crystallization.

Fluid Flow Equipment

Pipe fittings: Pumps, compressors and blowers. Chemical reactors; isothermal and non-isothermal operations. Concepts of reactor stability.

Case studies of operations

Paper and pulp manufacturing, Thermal power plant, Iron and steel manufacturing, Petrochemical refinery.

Text Books:

1. McCabe W.L.Smith J.C., Peter Harriot: Unit operations of chemical engineering, McGraw Hill, 7th Edition.2005.
2. Austin G.T, Shreve's chemical process industries, McGraw Hill International Edition.1985.

Course Outcome:

On completion of this course, the students will be knowledgeable in,

1. operations of various process in chemical industry.
2. the basics of heat mass and momentum transfer.
3. the operation of various fluid flow equipments used in chemical industries.

ICPE19 – MEASUREMENT DATA ANALYSIS

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

Course Objectives:

1. 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.
2. To introduce the fundamental techniques of measurement and data analysis and to report the results of an experiment.

Course Content:

General information about measurements, measuring instruments and their properties.

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

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

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

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

Text Books:

1. *Semyon G. Rabinovich, Measurement Errors and Uncertainities – Theory and Practice, Springer Publication, 3rd Edition, 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:

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

1. estimate measurement inaccuracies.
2. evaluate the measurement system based on its quality and cost.
3. acquire both theoretical knowledge and practical skills in working with measurement data.
4. design and conduct experiments to analyze and interpret the data and generate reports.

ICPE20 - BUILDING AUTOMATION

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

Course Objectives:

1. To introduce the basic blocks of Building Management System.
2. To impart knowledge in the design of various sub systems (or modular system) of building automation.

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

Fire & 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. Introduction to structural health monitoring and methods employed.

Text Books:

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

Reference Books:

1. *Albert Ting-Pat So, WaiLok Chan, Intelligent Building Systems Kluwer Academic publisher, 3rd Edition, 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:

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

1. understand the concept behind building automation.
2. plan for building automation.
3. design sub systems for building automation and integrate those systems.

ICPE21 - DIGITAL CONTROL SYSTEMS

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

Course Objectives:

1. To impart knowledge in the significance and features of design of discrete- time control system.
2. To review on the different transform techniques for digital control system design.
3. To impart knowledge on the techniques to analyse the system performance in the discrete-time domain.
4. To impart knowledge in discrete state space controller design.

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-plane, z-plane and 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. Solution of discrete-time state equation. Computational methods.

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
Full order and reduced order discrete observer design - Kalman filter and extended Kalman filter design.

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 Time Control Systems, Prentice Hall India, 2^{nd} edition, 2005.*
2. *M. Gopal, Digital Control and state variable methods, Tata McGraw Hill, 3^{rd} edition., 2008.*

Reference Books:

1. *R. Isermann, Digital Control Systems Vol 1&2, Springer-Verlag, 1991.*
2. *B. C. Kuo, Digital Control System, Oxford University Press, 2^{nd} edition., 2007.*

Course Outcomes:

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

1. analyze the performance and stability of a discrete-time control system.
2. design discrete controllers for continuous-time system using classical methods.
3. design discrete controllers for continuous-time system using state space technique.
4. develop discrete state space observer.

ICPE22 - NEURAL NETWORKS AND FUZZY LOGIC

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

Course Objectives:

1. To provide an overview of intelligent techniques.
2. To introduce different architectures and algorithms of Neural Networks.
3. To impart knowledge on Fuzzy set theory and Fuzzy rules.

Course Content:

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent 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, Prentice Hall Inc., New Jersey, 2nd Edition, 1999.*
2. *Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, Prentice Hall, New Delhi, 1994.*
3. *Zdenko Kovacic, Stjepan Bogdan, Fuzzy Controller Design Theory and Applications, CRC Press, 1st edition, 2006.*
4. *Satish Kumar, Neural Networks–A classroom approach, Tata McGraw-Hill Publishing Company Limited, 2013.*

Course Outcomes:

On completion of this course, the students will be,

1. familiar with the basic concepts of Neural Network and Fuzzy logic.
2. able to develop Neural Network based modelling and control for different process applications.
3. able to design Fuzzy logic based control system for process applications.

ICPE23 – NONLINEAR CONTROL

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

Course Objectives:

1. To introduce and elaborate the characteristics of nonlinear systems
2. To teach the methods to analyze nonlinear systems.
3. To impart knowledge in the stability analysis of nonlinear systems using Lyapunov method.
4. To teach the control methods as applicable to nonlinear systems with case studies.

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, Prentice Hall Englewood Cliffs, New Jersey, 3rd Edition, 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, Westview Press, 2nd Edition, 2014.*

Course Outcomes:

On completion of this course, the students will be able to,
1. differentiate between linear and nonlinear systems and their behaviour.
2. apply the various methods of describing nonlinear systems and analyze the performance.
3. evaluate the stability using the Lyapunov theory.
4. decide the control method and design suitable nonlinear control system.

ICPE24 – SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL

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

Course Objectives:

1. To impart knowledge about the importance of system identification and adaptive control.
2. To teach about the parametric and nonparametric model for system identification and estimation techniques.
3. To expose students to the design of adaptive control technique.

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, and 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, Prentice-Hall, 2nd Edition, 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, 2nd Edition, 2008.*
4. *S. Sastry and M. Bodson, Adaptive Control: Stability, Convergence, and Robustness, Prentice-Hall, 1989.*

Course Outcomes:

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

1. identify the model structure & order determination for an unknown process.
2. apply estimation techniques for parametric & nonparametric models.
3. develop an adaptive control schemes for time varying systems.

ICPE25 - FAULT DETECTION AND DIAGNOSIS

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

Course Objectives:

1. To impart knowledge in fault detection and identification.
2. To introduce different structure residual technique for the fault identification.
3. To introduce different directional residual technique for the fault identification.

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, Macel Dekker, 2nd Edition, 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:

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

1. identify the different type of faults occurred in a system.
2. apply mathematical techniques to detect faults.
3. apply structured and directional techniques for FDI design.

ICPE26 - COMPUTATIONAL TECHNIQUES IN CONTROL ENGINEERING

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

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

1. *B.N. Datta,Numerical Methods for Linear Control Systems, Academic Press/Elsevier, 2005 (Low cost Indian edition available including CD ROM).*
2. *G.H. Golub & C.F. Van Loan, Matrix Computations, 4th, 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:

On completion of this course, the students will,

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

ICPE27 - PROCESS MODELLING AND OPTIMIZATION

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPE18
No. of Credits: 3

Course Objectives:

1. To introduce different modelling techniques both analytical and model driven.
2. To impart knowledge in objective function formulation and optimization techniques.
3. To familiarize students with the use of optimization tools in process modelling and simulation.

Course Content:

Definition of process model, physical and mathematical modeling, deterministic and stochastic process, classification of models, model building, black-box model, white box model, gray model, classification of mathematical methods.

Mathematical models of chemical engineering systems: Introduction, uses of mathematical models, scope of coverage, principles of formulation, fundamental laws, continuity equations, energy equations, equation of motion, transport equation, equation of state, equilibrium, kinetics.
Examples of mathematical models of chemical engineering systems

The nature and organization of optimization problems: Scope and hierarchy of optimization, examples of applications of optimization, the essential features of optimization problems, general procedure for solving optimization problems, obstacles to optimization.

Developing models for optimization: Classification of models, selecting functions to fit empirical data, factorial experimental designs, degrees of freedom, formulation of the objective function. Basic concepts of optimization: Continuity of function, NLP problem statement, convexity and its applications, interpretation of the objective function in terms of its quadratic approximation, necessary and sufficient conditions for an extremum of an unconstrained function.

Optimization of unconstrained functions: One-dimensional search numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton and Quasi-Newton methods of uni-dimensional search, polynomial approximation methods, how one-dimensional search is applied in a multidimensional problem, evaluation of uni-dimensional search methods.
Application of optimizations: Examples of optimization in chemical processes.

Text Books:

1. *B Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Inc. 1st Edition, 1998.*
2. *William L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, McGraw Hill International Editions, 2nd Edition,1989.*
3. *Edger, Himmelblau, Lasdon, Optimization of Chemical Processes, McGraw-Hill International Edition, 2nd Edition, 2001.*

4. *MC Joshi and K M Moudgalya, Optimization: Theory and Practice, Narosa Publishing, 1st Edition,2013.*

Reference Books:

1. *Singiresu S. Rao, Engineering Optimization Theory and Practices, John Wiley & Sons, 4th Edition, 2009.*
2. *W D Seider, J D Seader and D R Lewin, Product and Process Design Principles-Synthesis, Analysis, and Evaluation, John Wiley and Sons Inc, 3rd Edition 2012.*
3. *Gordon S. G. Beveridge and Rober S. Schechter, Optimization: Theory and Practice, McGraw-Hill Book Company, 1st Edition, 2010.*
4. *K. Deb, Optimization for Engineering Design, Prentice-Hall India learning private limited, 2nd Edition, 2012.*

Course Outcomes:

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

1. use process models based on conservation principles and process data.
2. simulate the chemical processes.
3. apply the computational techniques to solve the process models.
4. utilize the principles of engineering to develop equality and inequality constraints.
5. know about and use optimization as a tool in process design and operation.

ICPE28 – CONTROL SYSTEM COMPONENTS

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

Course Objectives:

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

Course Content:

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

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

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

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

Text Books:

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

Reference Books:

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

Course Outcomes:

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

1. select and use the components for electrical systems.
2. identify, formulate and solve a problem using pneumatic system in instrumentation and control engineering.
3. identify, formulate and solve a problem using hydraulic system in instrumentation and control engineering.

ICPE29 – NETWORK CONTROL SYSTEMS

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

Course Objectives:

1. To impart knowledge in different network models.
2. To introduce different network control system techniques.
3. To introduce different applications suited for network control systems.

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

Reference Books:

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

Course Outcomes:

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

1. design control system in the presence of quantization, network delay or packet loss.
2. understand distributed estimation and control suited for network control system.
3. develop simple application suited for network control systems.

ICPE30 - DIGITAL SIGNAL PROCESSING

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

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

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

Reference Books:

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

Course Outcomes:

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

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

ICPE31 - POWER ELECTRONICS

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

Course Objectives:

1. To introduce the students about the theory and applications of power electronic systems for high efficiency, renewable and energy saving conversion systems.
2. To impart knowledge on the characteristics of different power electronics switches, drivers and selection of components for different applications.
3. To teach about the switching behavior and design of the converter and inverter circuits.

Course Content:

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

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

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

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

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

Applications in power electronics: UPS, SMPS and Drives.

Text Books:

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

Reference Books:

1. *Vedam Subramanyam K, Power Electronics, New Age International Publishers, New Delhi, 2nd Edition, 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:

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

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

ICPE32 REAL-TIME EMBEDDED SYSTEMS

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

Course Objectives:

1. To introduce the basic concepts of Embedded Systems
2. To expose to the design principles of advanced level ARM processors.
3. To provide basic understanding of the concepts of OS and RTOS.

Course Content:

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

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

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

Text Books:

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

Reference Books:

1. *Cortex M4 Technical Reference Manual: ARM Rev r0p0*
2. *TIVA ARM Cortex M4F Datasheets*
3. *ARMv7-M Architecture Reference Manual.*

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

1. design embedded system for simple applications.
2. write application programs in embedded C and test the programs using CCS.
3. develop application programs for execution under TI-RTOS environment.

ICPE33 - SMART AND WIRELESS INSTRUMENTATION

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

Course Objectives:

1. To expose to the basics of sensors used in industries.
2. To provide adequate knowledge on smart instrumentation and wireless sensor networks.
3. To impart knowledge on various standard protocols used in wireless instrumentation.

Course Content:

Sensor Classification-Thermal sensors-Humidity sensors-Capacitive Sensors-Planar Inter digital Sensors-Planar Electromagnetic Sensors-Light Sensing Technology-Moisture Sensing Technology-Carbon Dioxide (CO_2) sensing technology-Sensors Parameters

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

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

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. Digital light processor (DLP)

Text Books:

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

Reference Books:

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

Course Outcomes:

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

1. design self-diagnosing instrumentation system.
2. identify 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*:** -
No. of Credits: 3

Course Objectives:

1. To introduce the fundamentals of image processing.
2. To introduce to the various image processing techniques.
3. To impart knowledge on the design and realization of various image processing applications.

Course Content:

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

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

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

Image Segmentation:
Image segmentation - point, line and edge detection, Thresholding, Regions Based segmentation, segmentation using morphological watersheds, usage of motion in segmentation, edge linking and boundary detection, 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, Pearson education, 3rd Edition, 2008.*
2. *Jain Anil K., Fundamentals Digital Image Processing, Prentice Hall India, 2010.*

Reference Books:

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

Course Outcomes:

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

1. apply knowledge of mathematics for image understanding and analysis.
2. design, realize and troubleshoot various algorithms for image processing case studies.
3. 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 Objectives:

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

Course Content:

Multisensor data fusion: Introduction, sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data fusion, Mathematical tools used: Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta - heuristics.

Taxonomy of algorithms for multisensor data fusion. Data association. Identity declaration.

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

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

High performance data structures: Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system.

Text Books:

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

Reference Books:

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

Course Outcomes:

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

1. identify and characterise the principle components of data fusion and information systems.
2. apply the concepts of data fusion in sensing.
3. select fusion techniques appropriate to system and mission needs.

ICPE36 – MEDICAL IMAGING SYSTEMS

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

Course Objectives:

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

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, 4th Edition, 2005.*
2. *W.Peggy, Roger D.Ferimarch, MRI for Technologists, Mc Graw Hill, New York, 1995.*
3. *Flower M.A., Webb's Physics of Medical Imaging, Taylor & Francis, New York, 2nd Edition, 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, 2nd Edition, 2007.*
2. *Jerry L.Prince and Jonathan M. Links, Medical Imaging Signals and Systems- Pearson Education Inc., 2nd Edition, 2014.*

3. Kavyan Najarian and Robert Splinter, Biomedical signals and Image processing, CRC press, New York, 2nd Edition, 2012.

Course Outcomes:

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

1. acquire basic domain knowledge about the various medical imaging techniques.
2. understand the construction and working of various medical imaging equipments.
3. analyze the medical images for diagnosis.

ICPE37 - INDUSTRIAL DATA COMMUNICATION

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

Course Objectives:

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

1. To expose the students to communication systems emerging in the field of instrumentation.
2. To introduce to the system interconnection and protocols.
3. To give an overview of data communication standards.

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

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

1. explain the rationale behind the technological development of industrial networks.
2. understand various industrial network communication protocols.
3. evaluate and select protocol for particular application.

ICPE38 - ENERGY HARVESTING TECHNIQUES

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

Course Objectives:

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

Course Content:

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

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

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

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

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

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

Text Books:

1. *Shashank Priya and Daniel J.Inman, Energy Harvesting Technologies, Springer-Verlag New York, Inc., 1st Edition, 2010.*
2. *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,1st Edition ,2010.*
2. *Alper Erturk and Daniel J Inman, Piezoelectric Energy Harvesting, John Wiley and Sons.Ltd.1st Edition ,2011.*
3. *Tom J.Kazmiershi, Steve Beeby, Energy Harvesting System, Principles,Modelling and Application, springer, Newyork, 2011.*

Course Outcomes:

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

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

ICPE39 – SMART MATERIALS AND SYSTEMS

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

Course Objectives:

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

Course Content:

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

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

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

Shape Memory Alloys (SMA) – Phase Transformations, Basic Material 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, Chapman & Hall Publishers, 1st Edition, 1992.*
2. *Mel Schwartz, Encyclopedia of smart materials, John Wiley and Sons, 1st Edition,2002.*
3. *Srinivasan A.V., Michael McFarland D., Smart Structures Analysis and Design, Cambridge University Press, 1st Edition, 2010.*
4. *Culshaw B., Smart structures and Materials, Artech house, 1st Edition, 2004.*
5. *Leo, D.J. Engineering Analysis of Smart Material Systems, John Wiley & sons, 1st Editon 2008.*
6. *R.C.Smith, smart material systems: model development, frontiers in applied mathematics, SIAM, 2005.*
7. *H.Janocha, Adaptronics and smart structures: Basics, Materials, Design,and Applications, springer, 2nd Edition, 2007.*

Reference Material:

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

Course Outcomes:

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

1. acquire knowledge about the smart materials, their characteristics and design aspects.
2. design, model and control smart materials based structures/systems, through simulation and experimentation.
3. analyze and design techniques, to offer solutions to industrial problems using smart materials.

ICPE40 - HYDRAULICS AND PNEUMATICS

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

Course Objectives:

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

Course Content:

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

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

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

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

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

Text Books:

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

Reference Books:

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

Course Outcomes:

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

1. acquire knowledge about working of hydraulic and pneumatic systems.
2. identify the controlling components of hydraulic and pneumatic systems.
3. select and prepare a distribution system for compressed air.
4. compile the design of hydraulic and pneumatic systems and analyze them.
5. demonstrate the need of pressure and time dependent controls.

ICPE41 – INTERNET OF THINGS SYSTEM DESIGN

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

Course Objectives:

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

Course Content:

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

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

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

Text Books:

1. *Joe Biron & Jonathan Follett, Foundational Elements of an IoT Solution – The Edge, The Cloud and Application Development, Oreilly,1st Edition, 2016.*

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

Reference Books:

1. *The Internet of Things – Opportunities and Challenges*
   http://www.ti.com/ww/en/internet_of_things/pdf/14-09-17-IoTforCap.pdf
2. Single Chip Controller and 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:

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

1. understand the design architecture of IoT.
2. make choice of protocols and deployment in solutions.
3. comprehend the design perspective of IoT based products /services.

ICPE42 – SOFTWARE DESIGN TOOLS FOR SENSING AND CONTROL

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPC11, ICPC21

No. of Credits: 3

Course Objectives:

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

Course Content:

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

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

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

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

Text Books:

1. *Roger W. Pryor, Multiphysics Modeling Using COMSOL®: A First Principles Approach, Jones and Bartlett Publishers, 1st Edition, 2011.*
2. *Tamara Bechtold, Gabriela Schrag and Lihong Feng, System-level Modeling of MEMS, Wiley-VCH verlag GmbH & Co, 1st Edition, 2013.*
3. *Holly Moore, MATLAB for Engineers, Pearson Education, 5th Edition, 2017.*

4. *Brian Hahn and Daniel Valentine, Essential MATLAB for Engineers and Scientists, Elsevier, Acadamic press, 6th edition, 2016.*

Reference Books:

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

Course Outcomes:

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

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

ICPE43 - INDUSTRIAL ELECTRIC DRIVES

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

Course Objectives:

1. To introduce to the students on the concept of employing power convertors for the design of electric drives.
2. To impart knowledge on the analysis of electric drive system dynamics.
3. To impart knowledge on the design and development of control methods for electric drive systems.

Course Content:

Electric Drive System - Dynamics and steady state stability

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

DC motor drives – dc motors & 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:

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

1. design suitable power electronic circuit for an electric drive system and analyse its steady state stability.
2. select appropriate control method for the electric drives.
3. select a suitable electric drive for a particular industrial application.

ICPE44 – PIPING AND INSTRUMENTATION DIAGRAMS

Course type: Programme Elective (PE) ***Pre-requisites*:** ICPE18
No. of Credits: 3

Course Objectives:

1. To introduce various flow sheet design using process flow diagram.
2. To impart knowledge on P&I D symbols for pumps, compressors and process vessels.
3. To teach the line diagram symbols, logic gates of instruments.

Course Content:

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

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

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

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

Application of P& ID'S: Applications of P& ID in design state, construction stage, commissioning state, operating stage, revamping state, applications of P&ID in HAZAMPS and risk analysis

Text Books:

1. Ernest E.Ludwig, Applied Process Design for Chemical and Petrochemical Plants Vol-1, Gulf Publishing Company,Hoston,1989.
2. Max. S. Peters and K.D.Timmerhaus, Plant Design and Economics for Chemical Engineers, McGraw Hill Inc., New York, 1991.

Reference Books:

1. Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGraw Hill, New Delhi, 1981.
2. A.N.Westerberg et al., Process Flowsheeting, Cambridge University Press, New Delhi,1979.

Course Outcomes:

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

1. understand of P&I diagrams standards involved and its preparation.
2. select different fittings for instruments installation used for the preparation of P&IDs.
3. to use software for preparation of P&IDs.

ICPE45 – ROBOTICS

Course type: Programme Elective (PE) ***Pre-requisites:*** ICPC21, ICPC24

No. of Credits: 3

Course Objectives:

1. To introduce robotics in the fields of manufacturing, medicine, search and rescue, service, and entertainment.
2. To teach robotics as the synergistic integration of mechanics, electronics, controls, and computer science.

Course Content:

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

Introduction to automation: Components and subsystems, basic building block of automation, manipulator arms, wrists and end-effectors. Transmission elements: Hydraulic, pneumatic and electric drives. Gears, sensors, materials, user interface, machine vision, implications for robot design, controllers.

Kinematics, dynamics and control: Object location, three dimensional transformation matrices, inverse transformation, kinematics and path planning, Jacobian work envelope, manipulator dynamics, dynamic stabilization, position control and force control, present industrial robot control schemes.

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

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

Text Books:

1. Spong, M.W., Hutchinson, H., & Vidyasagar, M., Robot Modeling and Control, John Wiley (Wiley India Ed.), 2006.
2. Asfahl C.R, Robots and Manufacturing Automation, John Wiley & Sons, New York, 1992.
3. Klafter R.P, Chmiclewski T.A, Negin M, Robotics Engineering: Integrated approach, Prentice Hall, New Jersey, 1994.

Reference Books:

1. Mikell P, Weiss G.M, Nagel R.N and Odrey N.G, Industrial Robotics, McGraw Hill, New York, 1986.
2. Deb S.R, Robotics Technology and Flexible Automation, Tata McGraw Hill, New Delhi, 1994

Course Outcomes:

On completion of this course, the students will,

1. learn the mathematics of rigid motions, rotations, translations, velocity kinematics.
2. be introduced to the most popular methods for motion planning and obstacle avoidance.
3. understand robot dynamics and multivariable control.
4. be familiar with computer vision, visual servo control problems and applications in the industry.

Open Elective (OE) Courses

ICOE10 - BUILDING AUTOMATION

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

Course Objectives:

1. To introduce the basic blocks of Building Management System.
2. To impart knowledge in the design of various sub systems (or modular system) of building automation.

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

Fire & alarm system:
Different fire sensors, smoke detectors and their types, CO and CO_2 sensors, Fire control panels, design considerations for the FA system concept of IP enabled fire & 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. Introduction to structural health monitoring and methods employed.

Text Books:

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

Reference Books:

1. *Albert Ting-Pat So, WaiLok Chan, Intelligent Building Systems Kluwer Academic publisher, 3rd Edition, 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:

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

1. understand the concept behind building automation.
2. plan for building automation.
3. design sub systems for building automation and integrate those systems.

ICOE11 – PROJECT ENGINEERING AND MANAGEMENT

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

Course Objectives:

1. To introduce students the concept of project engineering and management.
2. To make students understand the flow of engineering project and related documentation.
3. To create awareness on management and financial functions and usage of relevant tools.

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 Edition, 2008.*
2. *Harlod Kerzner and Van Nostrand, Project management: A systems approach to planning scheduling and controlling, Reinhold Publishing, 11th Edition, 2010.*

Reference Books:

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

Course Outcomes:

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

1. understand the different types of projects and its management.
2. understand project management and the financial tools.
3. design different documents and apply relevant tools.

ICOE12 - MEDICAL INSTRUMENTATION

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

Course Objectives:

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

1. To educate the students on the different medical instruments.
2. To familiarise the students with the analysis and design of instruments to measure bio signals like ECG, EEG, EMG, etc.
3. To introduce about the applications of biomedical instrumentation.

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, 2nd Edition, Prentice Hall of India, New Delhi, 2001.*
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, 3rd edition, Tata McGraw Hill education, New Delhi, 2014.*

Course Outcomes:

On completion of this course the students will be,

1. able to understand, design and evaluate systems and devices that can measure, test and/or acquire biological information from the human body.
2. familiar with patient monitoring equipment used in hospitals and in telemedicine.
3. familiar with various imaging techniques used for diagnosis.

ICOE13 - MICRO ELECTRO MECHANICAL SYSTEMS

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

Course Objectives:

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 provide knowledge in the design concepts of micro sensors and micro actuators.
4. To provide 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, CRC Press, 2nd Edition, 2002.*
3. *Julian W. Gardner and Vijay K. Varadan, Microsensors, MEMS, and Smart Devices, John Wiley & Sons Ltd, 1st Edition, reprinted 2007.*

Reference Books:

1. *Elwenspoek, Miko, Wiegerink, R, Mechanical Microsensors, Springer*-Verlag Berlin Heidelberg GmbH*, 1st Edition, 2001.*
2. *Simon M. Sze, Semiconductor Sensors, John Wiley & Sons. Inc, 1st Edition, 1994.*
3. *Chang Liu, Foundations of MEMS, Pearson Educational limited, 2nd Edition, 2011.*

Course Outcomes:

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

1. understand the fundamental principles behind the working of micro devices/ systems and their applications.
2. gain a fundamental understanding of standard micro fabrication techniques.
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.

ICOE14 - MEASUREMENT AND CONTROL

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

Course Objectives:

1. To impart knowledge in the basics of measurement system.
2. To expose the students to various measurement techniques used for the measurement of important process variables.
3. To expose the students to the basics of control systems.

Course Content:

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

Reference Books:

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

Course Outcomes:

On completion of this course the students will be,

1. familiar with the basics of measurement system, its characteristics and principles of few transducers.
2. familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
3. able to select and make measurements of temperature, flow, pressure and level in any process industry.
4. familiar with the concept of closed loop control system.

ICOE15 - INDUSTRIAL MEASUREMENTS

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

Course Objectives:

1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
3. To make the students knowledgeable in the design, installation and trouble shooting of process instruments.

Course Content:

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

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

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

Reference Books:

1. *B.E.Noltingk, Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.*
2. *Douglas M. Considine, Process / Industrial Instruments & Controls Handbook, McGraw Hill, Singapore, 5th Edition, 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:

On completion of this course, the students will be,

1. familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
2. able to select and make measurements of temperature, flow, pressure and level in any process industry.
3. able to identify or choose temperature, flow, pressure and level measuring device for specific process.

ICOE16 – VIRTUAL INSTRUMENT DESIGN

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

Course Objectives:

1. To introduce to the students about the interfacing techniques of various transducers.
2. To expose the students to different signal conditioning circuits.
3. To impart knowledge on the hardware required to build Virtual Instrument.
4. To impart knowledge to build GUI for Virtual Instrument.

Course Content:

Transducer Interfacing:
Interfacing techniques for the following transducers: Potentiometers - Temperature sensors – Thermocouple, RTD, Thermistors – Load cells – High and low range tension, Low and mid range precision – Torque Sensors –Pressure sensors – Vibration Sensors – Acoustic Sensors – Automotive Sensors – Displacement sensors – Biomedical transducers.

Signal Conditioning:
Filtering, Cold Junction Compensation, Amplification, Instrumentation Amplifier – Linearization – 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:

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

1. interface the target transducer to the signal conditioning board.
2. condition the acquired signal from the transducer to standard data formats.
3. select the most appropriate hardware for the virtual instrument to be built.
4. implement the real-time OS for the selected micro-controller and the GUI interface for the virtual instrument.

ICOE17 - NEURAL NETWORKS AND FUZZY LOGIC

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

Course Objectives:

1. To provide an overview of intelligent techniques.
2. To introduce different architectures and algorithms of Neural Networks.
3. To impart knowledge on Fuzzy set theory and Fuzzy rules.

Course Content:

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent 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, Prentice Hall Inc., New Jersey, 2nd Edition, 1999.*
2. *Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, Prentice Hall, New Delhi, 1994.*
3. *ZdenkoKovacic, StjepanBogdan, Fuzzy Controller Design Theory and Applications, CRC Press, 1st Edition, 2006.*
4. *Satish Kumar, Neural Networks–A classroom approach, Tata McGraw-Hill Publishing Company Limited, 2013.*

Course Outcomes:

On completion of this course, the students will be,

1. familiar with the basic concepts of Neural Network and Fuzzy logic.
2. able to develop Neural Network based modelling and control for different process applications.
3. able to design Fuzzy logic based control system for process applications.

ICOE18 - NETWORK CONTROL SYSTEMS

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

Course Objectives:

1. To impart knowledge in different network models.
2. To introduce different network control system techniques.
3. To introduce different applications suited for network control systems.

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

Reference Books:

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

Course Outcomes:

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

1. design control system in the presence of quantization, network delay or packet loss.
2. understand distributed estimation and control suited for network control system.
3. develop simple application suited for network control systems.

ICOE19 – CONTROL SYSTEMS

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

Course Objectives:

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

Course Content:

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

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

The Root Locus Method, Feedback Control System Analysis & 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, Prentice Hall, 13th Edition, 2016.*
2. *Katsuhiko Ogata, "Modern Control Engineering", PHI Learning Private Ltd, 5th Edition, 2010.*
3. *Franklin, G.F., David Powell, J., Emami-Naeini, A., Feedback Control of Dynamic Systems, Prentice Hall, 7th Edition, 2014.*

Reference Books:

1. *Nise, N.S., Control Systems Engineering, Wiley, 7th Edition, 2015.*
2. *John J.D., Azzo Constantine, H. and Houpis Sttuart, N Sheldon, Linear Control System Analysis and Design with MATLAB, CRC Taylor& Francis Reprint 2009.*
3. *Dutton, K., Thompson, S., Barralough, B., The Art of Control Engineering, Prentice Hall, 1997.*

Course outcomes:

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

1. generate mathematical models of dynamic control system by applying differential equations.
2. analyze and characterize the behavior of a control system in terms of different system and performance parameters.
3. compute and assess system stability.
4. evaluate and analyses system performance using frequency and transient response analysis.
5. design and simulate control systems (linear feedback control systems, PID controller, and multivariable control systems), using control software, to achieve required stability, performance and robustness.
6. critically analyses and outline the dynamic response of closed loop systems.

ICOE20 - ENERGY HARVESTING TECHNIQUES

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

Course Objectives:

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

Course Content:

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

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

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

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

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

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

Text Books:

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

Reference Books:

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

Course Outcomes:

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

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

ICOE21 – INTERNET OF THINGS

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

Course Objectives:

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

Course Content:

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

System Design of Connected Devices : Embedded Devices, Embedded Hardware, Connected Sensors and Actuators, Controllers, Battery Life Conservation and designing with Energy Efficient Devices, SoCs, 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. *Joe Biron & Jonathan Follett, Foundational Elements of an IoT Solution – The Edge, The Cloud and Application Development, Oreilly,1st Edition, 2016.*
2. *Designing Connected Products, Elizabeth Goodman, Alfred Lui,Martin Charlier, Ann Light, Claire Rowland1st Edition.*
3. *The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, Lucas Darnell, 2016.*

Reference Books:

1. *The Internet of Things – Opportunities and Challenges*
   http://www.ti.com/ww/en/internet_of_things/pdf/14-09-17-IoTforCap.pdf
2. *Single Chip Controller and 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:

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

1. understand the design architecture of IoT.
2. make choice of protocols and deployment in solutions.
3. comprehend the design perspective of IoT based products /services.

ICOE22 – INTELLECTUAL PROPERTY RIGHTS

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

Course Objectives:

1. To introduce the students about the need to be aware of IPR and the knowledge on IPR.
2. To make the students understand how IPR contributes to the economic development of the society and in turn to the nation.
3. To teach that IP is a law, economics, technology and business.
4. To make students realize 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 NIT '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 Edition. 2007.*

Reference Books:

1. *Robert P. Merges, Peter S. Meneil, Mark A. Lemley, Intellectual Property in New Technological Age, Aspen Publishers, 4th Edition, 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:

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

1. familiar with and realize the importance of IPR.
2. familiar with and realize how IPR are regarded as a source of national wealth and mark of an economic leadership in the context of global market scenario.
3. able to understand how IPR contributes to the economic development of the society.

ICOE23 – SMART MATERIALS AND SYSTEMS

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

Course Objectives:

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

Course Content:

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

Reference Material:

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

Course Outcomes:

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

1. acquire knowledge about the smart materials, their characteristics and design aspects.
2. design, model and control smart materials based structures/systems, through simulation and experimentation.
3. analyze and design techniques, to offer solutions to industrial problems using smart materials.

Courses for B. Tech Minor (MI) Programme

ICMI10 – TRANSDUCER ENGINEERING

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

Course Objectives:

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

Course Content:

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

Resistive transducers: Potentiometers, metal and semiconductor strain gauges and signal conditioning circuits, strain gauge applications: Load and torque measurement, Digital displacement transducer.

Self and mutual inductive transducers- capacitive transducers, eddy current transducers, proximity sensors, tacho-generators and stroboscope.

Piezoelectric transducers and their signal conditioning, Seismic transducer and its dynamic response, photoelectric transducers, Hall effect sensors, Magnetostrictive transducers, Basics of Gyroscope.

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

Text Books:

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

On completion of this course, the students will be,

1. familiar with the basics of measurement system and its input, output configuration.
2. familiar with both static and dynamic characteristics of measurement system.
3. familiar with the principle and working of various sensors and transducers.
4. able to design signal conditioning circuit for various transducers.
5. able to select proper transducer / sensor for a specific measurement application.

ICMI11 – TEST AND MEASURING INSTRUMENTS

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

Course Objectives:

1. To give an overview of current, voltage and power measuring electrical, electronics and digital instruments.
2. To expose the students to the design of bridges for the measurement of resistance, capacitance and inductance.
3. To give an overview of test and measuring instruments.

Course Content:

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

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

Different methods of measuring low, medium and high resistances, measurement of inductance & capacitance with the help of AC Bridges, Q Meter.

Digital Measurement of Electrical Quantities: Concept of digital measurement, block diagram Study of digital voltmeter, Digital multimeter, Digital LCR meter, Digital wattmeter and energy meters.

DSO, Function generator, Audio frequency signal generation, Waveform analyzers, Spectrum analyzers.

Text Books:

1. *Golding, E.W. and Widdis, F.C., Electrical Measurements and Measuring Instruments, A.H.Wheeler and Co, 5th Edition, 2011.*
2. *David A. Bell, Electronic Instrumentation and Measurements, Oxford University Press, 3rd Edition, 2013.*
3. *Shawney A K, A course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Sons. 19th revised edition, 2013.*

Reference Books:

1. *Cooper, W.D. and Helfric, A.D., Electronic Instrumentation and Measurement Techniques, Prentice Hall, 1st Edition, 2009.*
2. *Kalsi.H.S, Electronic Instrumentation, Tata Mcgraw Hill Education Private Limited, 3rd Edition, 2012.*

Course Outcomes:

On completion of this course, the students will be,

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

ICMI12 – MEASUREMENTS IN PROCESS INDUSTRIES

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

Course Objectives:

1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
3. To make the students knowledgeable in the design, installation and trouble shooting of process instruments.

Course Content:

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

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

Level measurement: Introduction, Capacitance pickup, Ultrasonic pickup.

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

Hot wire anemometer and ultrasonic flow meters. Calibration and selection of Flow meters

Text Books:

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

Reference Books:

1. *B.E.Noltingk, Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.*
2. *Douglas M. Considine, Process / Industrial Instruments & Controls Handbook, McGraw Hill, Singapore, 5th Edition, 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:

On completion of this course, the students will be,

1. familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
2. able to select and make measurements of temperature, flow, pressure and level in any process industry.
3. able to identify or choose temperature, flow, pressure and level measuring device for specific process.

ICMI13 – ESSENTIALS OF CONTROL ENGINEERING

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

Course Objectives:

1. To expose the students to the fundamentals of feedback control system.
2. To impart the knowledge on different types of control systems representation in pictorial and mathematical forms.
3. To teach the performance characteristics and analysis of control systems in time and frequency domain.

Course Content:

Introduction to control system – Open loop and Closed loop system – Feedback system characteristics – Block diagram reduction techniques – Signal flow graph.

Order and type of system – time domain and frequency domain response of different system characteristics using simulation software – Introduction of stability – Routh Hurwitz stability criteria.

Introduction to root locus – plotting of root locus and stability analysis using simulation software. Introduction to bode and Nyquist plot – Plotting of bode and Nyquist plot using simulation software - Gain Margin and Phase margin calculation.

Introduction to different compensator design – the design of different compensator design using simulation software. PID controller design using simulation software.

Application of control system for different domain with case studies.

Text Books:

1. *Dorf, R.C., & Bishop, R.H., Modern Control Systems, Prentice Hall, 13th Edition, 2016.*
2. *Katsuhiko Ogata Modern Control Engineering, Pearson, 5th Edition, 2009.*

Reference Books:

1. *Franklin G.F., Powell J.D., Emami-Naeini A., Feedback Control of Dynamic Systems, Pearson, 7th Edition, 2015.*
2. *B. C. Kuo, F. Golnaraghi, Automatic Control Systems, Wiley Publishers, India, 8th Edition, 2003.*
3. *Ramakalyan A., Control Engineering- A comprehensive foundation, Vikas Publication, New Delhi, 2004.*
4. *Norman S. Nise, Control Systems Engineering, Wiley India publications, 4th Edition, 2003.*

Course Outcomes:

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

1. appreciate the importance of feedback control system.
2. analyze and design the system performance using time domain and frequency domain techniques.
3. use simulation software for classical control system design and analysis.

ICMI14 – INDUSTRIAL AUTOMATION AND CONTROL

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

Course Objectives:

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

Course Content:

Introduction and overview of Industrial automation – Block diagram of PLC – different types of PLC – Type of input and output – Introduction to relay logic- Application of PLC.

Introduction to Ladder logic programming – Basic instructions – Timer and Counter instruction- Arithmetic and logical instruction – MCR, PID controller and other essential instruction sets - Case studies and examples for each instruction set.

Introduction to high level PLC language – Programming of PLC using simulation software – Real time interface and control of process rig/switches using PLC.

Introduction to DCS and SCADA - Block diagram – function of each component – Security objective – Operation and engineering station interface – Communication requirements.

Development of different control block using DCS simulation software – Real time control of test rigs using DCS. Introduction to HART, Fieldbus and PROFIBUS – Application and case studies of large scale process control using DCS.

Text Books:

1. *John W. Webb and Ronald A Reis, Programmable Logic Controllers - Principles and Applications, Prentice Hall Inc., New Jersey, 5th Edition, 2002.*
2. *Lukcas M.P, Distributed Control Systems, Van Nostrand Reinhold Co., New York, 1986.*
3. *Frank D. Petruzella, Programmable Logic Controllers, McGraw Hill, New York, 4th Edition, 2010.*

Reference Books:

1. *Deshpande P.B and Ash R.H, Elements of Process Control Applications, ISA Press, New York, 1995.*
2. *Curtis D. Johnson, Process Control Instrumentation Technology, Prentice Hall, New Delhi, 8th Edition, 2005.*
3. *Krishna Kant, Computer-based Industrial Control, Prentice Hall, New Delhi, 2nd Edition, 2011.*

Course Outcomes:

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

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

Essential Programme Laboratory Requirement (ELR) Courses

ICLR10 – THERMODYNAMICS AND FLUID MECHANICS LABORATORY

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

Course Objectives:

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

List of Experiments:

Thermodynamics

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

Fluid Mechanics

1. Determination of pipe friction
2. Calibration of flow meters – 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, McGraw Hill, New York, 7th Edition 1997.*
2. *Ojha C.S.P., Berndtsson R., Chandramouli P.N., Fluid Mechanics and Machinery, Oxford University Press, 2010.*

Course Outcomes:

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

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

ICLR11 – CIRCUITS AND DIGITAL LABORATORY

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

Course Objectives:

1. To introduce to the design of passive, bilateral electrical circuits.

2. To impart knowledge in network analysis and realization.

3. To impart knowledge in design and verification of combinational and sequential logic circuits.

List of Experiments:

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

Reference Books:

1. *Hayt, W.H, Kemmerly J.E. & 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:

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

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

ICLR12 – SENSORS AND TRANSDUCERS LABORATORY

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

Course Objectives:

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

List of Experiments:

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

Reference Books:

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

Course Outcomes:

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

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

ICLR13 – ANALOG SIGNAL PROCESSING LABORATORY

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

Course Objectives:

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

List of experiments:

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

Text Books:

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

Course Outcomes:

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

1. design analog and digital system level circuit.
2. simulate and validate analog IC circuits using simulation software.
3. apply this basic IC circuit design concepts for application.

ICLR14 – INSTRUMENTATION LABORATORY

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

Course Objectives:

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

List of Experiments:

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

Reference Books:

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

Course Outcomes:

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

1. suggest a suitable temperature sensor for an application.
2. design the required conversion and manipulation circuits for temperature and pressure measurement systems.
3. evaluate various temperature and pressure measuring sensors.

ICLR15 – MICROPROCESSORS AND MICROCONTROLLERS LABORATORY

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

Course Objectives:

1. To impart knowledge in the interfacing the microprocessor with external peripherals.
2. To familiarize with ARM processor to learn how a program gets executed in a microprocessor/ microcontroller.
3. To fabricate a micro-controller circuit board using KiCAD open-source PCB design tool.
4. To teach students on programing 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 an 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:

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

1. program microprocessor/ micro-controller using a C language based compiler.
2. interface the peripherals with microprocessor and microcontrollers.
3. fabricate a micro-controller circuit board using KiCAD open-source PCB design tool.

ICLR16 – CONTROL ENGINEERING LABORATORY

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

Course Objectives:

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

List of Experiments:

1. Time response characteristics of a second order system.
2. Frequency response characteristics of a second order system.
3. Constant gain compensation in time and frequency domain.
4. Compensating Networks - Characteristics
5. Design of compensation networks - Lead, Lag, Lead-lag
6. Design of state feedback controller.
7. Observer design - full order and reduced order.

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:

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

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

ICLR17 – INDUSTRIAL AUTOMATION AND PROCESS CONTROL LABORATORY

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

Course Objectives:

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

List of Experiments:

1. Identification of FOPDT and SOPDT process using time domain and 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, 2nd 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:

On completion of this lab, the students will be able to,
1. design PID controller and tune the same for various process.
2. implement sequential logic control using PLC for a required application.
3. use the simulation tools for the design of controller for various process.

Advanced Level Courses for B. Tech (Honours)

ICHO10 – DESIGN OF SENSORS AND TRANSDUCERS

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

Course Objectives:

1. To provide fundamentals of various types of diaphragm design.
2. To familiarize with design of strain gauge, capacitive and inductive based transducers and its applications.
3. To furnish the knowledge on design of accelerometer and gyroscope.
4. To provide the basics of various chemical sensors and its design criterion.

Course Content:

Introduction to diaphragm; Diaphragm performance and materials, Design of flat diaphragms, flat diaphragms with rigid centre – 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, 1989.*
2. *James W. Dally, William F. Riley, Kenneth G. McConnell, Instrumentation for Engineering Measurements, Wiley, 1993.*
3. *Di Giovanni, Flat and Corrugated Diaphragm Design Handbook, CRC Press, 1982.*
4. *Fraden, Jacob, Handbook of Modern Sensors: Physics, Designs, and Applications, Springer, 3rd Editions, 1993.*

Reference Books:

1. *Richard S. Figliola, Donald E. Beasley, Theory and Design for Mechanical Measurements, John Wiley & Sons, Inc, 6th Edition, 1991.*
2. *Authors: Fraden, Jacob, Handbook of Modern Sensors: Physics, Designs, and Applications, Springe, 3rd Editions, 2010.*
3. *Alexander D. Khazan, Transducers and Their Elements: Design and Application, PTR Prentice Hall, 1994*

4. *Peter H. Sydenham, Richard Thorn, Handbook of Measuring System Design, Wiley, 2005.*

Course Outcomes:

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

1. select and design diaphragm for different practical applications.
2. design strain gauge based torque, force, load and pressure measurement systems.
3. design capacitance/ inductance transducers for the measurement of displacement, pressure and level.
4. acquire knowledge in design of accelerometer and gyroscope.

ICHO11 - INSTRUMENTATION SYSTEM DESIGN

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

Course Learning Objectives:

1. To impart knowledge in the design of signal conditioning circuit for different process variables.
2. To introduce about control valve sizing and section of pumps for practical applications.
3. To familiarize with the concepts of micro controller based design for process applications.

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, Routledge, 3rd Edition, 1997.*
2. *Considine D.M., Process Instruments and Controls Handbook, McGraw-Hill., 5th Edition 2009.*

Reference Books:

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

Course Outcomes:

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

1. design temperature, flow and level measurement system for process application.
2. analyze the requirement of control system components and suggest an appropriate design procedure.
3. design microcontroller based measurement and control system.

ICHO12 - MICRO SYSTEM DESIGN

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

Course Objectives:

1. To provide knowledge on MEMS design and various fabrication process.
2. To impart knowledge on mechanics of membranes and beams in micro scale.
3. To convey the design principles of electrostatic actuation and sensing.
4. To impart design knowledge on micro pressure sensor and micro accelerometer.
5. To provide knowledge on MEMS sensor integration and packaging.

Course Content:

Introduction, An approach to MEMS design, Basic introduction to fabrication, process integration.

Energy conserving transducer, Mechanics of membranes and beams

Electrostatic Actuation and Sensing, Effects of electrical excitation

Design of Micro pressure sensor and Micro accelerometer

Electronic Integration and Packaging

Text Books:

1. *Peter D.Senturia, Microsystem Design,Kluwer Academic Publishers, Boston,1st Edition, 2001.*

Reference Books:

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

Course Outcomes:

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

1. design and fabricate simple micro devices.
2. design and analyse simple mechanical structures used in sensor actuator.
3. design electrostatic based actuation and sensing devices, micro pressure sensor and micro accelerometer.
4. understand sensor integration and packaging techniques.

ICHO13 – CONTROL SYSTEM DESIGN

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

Course Objectives:

1. To impart knowledge in the concepts and techniques of linear and nonlinear control system analysis and synthesis in the modern control (state space) framework.
2. To teach the control design using the classical design principles
3. To teach the controller and observer designs

Course Content

Design of Feedback Control Systems: Introduction; Approaches to System Design; Cascade Compensation Networks; Phase-Lead Design Using the Bode Diagram; Phase-Lead Design Using the Root Locus; System Design Using Integration Networks; Phase-Lag Design Using the Root Locus; Phase-Lag Design Using the Bode Diagram; Design on the Bode Diagram Using Analytical Methods; Systems with a Pre-filter; Design for Deadbeat Response; Design Examples.

Design of State Variable Feedback Systems Introduction, State space representation of physical systems, State space models of some common systems like R-L-C networks, DC motor, inverted pendulum etc., Controllable Canonical Form, Observable Canonical Form, Diagonal Canonical Form, State transition matrix, Solution of state equations, Controllability and Observability, Full-State Feedback Control Design; Observer Design; Integrated Full-State Feedback and Observer; Tracking Reference Inputs; Internal Model Design; Design Examples.

Lyapunov's stability and optimal control positive/negative definite, positive/negative semi-definite functions, Lyapunov stability criteria, introduction to optimal control, Riccatti Equation, Linear Quadratic Regulator, Design Examples.

Text Books:

1. *Bernard Friedland, Control System Design: An Introduction to State-Space Methods (Dover Books on Electrical Engineering), Dover Publications Inc., 2005.*
2. *Gene F. Franklin, J. Da Powell, Abbas Emami-Naeini, Feedback Control of Dynamic Systems, Pearson Prentice Hall, 7th Edition, 2014.*
3. *Richard C Dorf, Robert H Bishop, Modern Control Systems, Pearson Education India, 12th Edition, 2013.*

Reference Books:

1. Katsuhiko Ogata, Modern Control Engineering, Pearson, 5th Edition, 2009.
2. Madan Gopal, Modern Control System Theory, New Age International Private Limited, 2014.

Course Outcomes:

On completing this course, the student would be able to,

1. develop mathematical models for various physical systems.
2. design state feedback controllers and observers.
3. design nonlinear controllers using Lyapunov theory.

ICHO14 - ADVANCED PROCESS CONTROL

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

Course Objectives:

1. To expose students to the advanced control methods used in industries and research.
2. To teach various system identification and parameter estimation techniques.
3. To prepare the student to take up such challenges in his profession.

Course Content:

Review of Single Input Single Output (SISO) Control; Model Based Control; Multivariable control strategies; Internal Model Control Preliminaries and Model Predictive Control, Model forms for Model Predictive Control, Model forms for Model Predictive Control; Parametric and Non-parametric Models, State space and Transfer Function Representations and their inter relationships; Control relevant process identification; Choice of Input Signals and Model Forms; Parameter Estimation using batch and Recursive Least Squares; Model Validations using Correlation Concepts; Identification of Non-parametric Representations; Model Predictive Control; Analysis of Dynamic Matrix Control (DMC) and Generalized Predictive Control (GPC) Schemes, Controller Tuning and Robustness Issues; Extensions to Constrained and Multivariable Cases.

Text Books:

1. *D.R. Coughanour, Process Systems analysis and Control, McGraw-Hill, 2nd Edition, 1991.*
2. *D.E. Seborg, T.F. Edger, and D.A. Millichamp, Process Dynamics and Control, John Wileyand Sons, 2nd Edition, 2004.*

Reference Books:

1. *B.A.Ogunnaike and W.H.Ray, Process Dynamics, Modelling and Control, Oxford Press, 1994.*
2. *W.L.Luyben, Process Modelling Simulation and Control for Chemical Engineers, McGraw Hill, 2nd Edition, 1990.*
3. *B.W. Bequette, Process Control: Modeling, Design and Simulation, PHI, 2006.*
4. *S. Bhanot, Process Control: Principles and Applications, Oxford University Press, 2008.*

Course Outcomes:

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

1. design an appropriate advanced controller for specific problems in chemical industry.
2. suggest a controller and tune its parameters.
3. design of controllers for interacting multivariable systems.

ICHO15 – OPTIMAL AND ROBUST CONTROL

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

Course Objectives:

1. To provide a basic knowledge of the theoretical foundations of optimal control.
2. To develop the skill needed to design controllers using available optimal control Theory and software.
3. To introduce to current research in optimization methods for robust control.

Course Content:

Linear Quadratic Control: The Linear Quadratic Regulator (LQR) problem: LQR solution using the minimum principle, Generalization of LQR; LQR properties with classical interpretations; Optimal observer design- Kalman-Bucy filter: Problem formulation and COURSES OF STUDY (Syllabus) M. Tech. (Instrumentation) for the batch registering in 2012-13 Solution, The Linear Quadratic Gaussian (LQG) problem: Introduction, LQG problem formulation and solution, Performance and Robustness of optimal state feedback, Loop Transfer Recovery (LTR).

Robust/H∞ Control: Introduction, Critique of LQG, Performance specification and robustness: Nominal performance of feedback system; Nominal performance: Multivariable case, Novel problem formulation of classical problem, Modeling uncertainty, Robust stability, Mathematical background: Singular Value Decomposition (SVD); Singular values and matrix norms; The supremum of functions, Norms and spaces, H2 Optimization and Loop Transfer Recovery (LTR), H∞ Control: A brief history, Notation and terminology, The two-port formulation of control problems; H∞ control problem formulation and assumptions; Problem solution, Weights in H∞ control problems, Design example.

Robust Control: The Parametric Approach: Stability theory via the boundary crossing theorem, The stability of a line segment, Interval polynomials: Kharitonov's theorem for real and complex polynomials, Interlacing and Image set interpretations, Extremal properties of the Kharitonov polynomial, Robust-state feedback stabilization, Schur stability of interval polynomials, The Edge theorem, The Generalized Kharitonov theorem, State space parameter perturbations, Robust stability of Interval matrices, Robustness using the Lyapunov approach, Robust parametric stabilization.

Text Books:

1. *J. M. Maciejowski, Multivariable Feedback Design, Addison-Wesley Publishing Company, 1989.*
2. *H. Kwakernaak and R. Sivan, Linear Optimal Control Systems, Wiley-Interscience, 1972.*
3. *B. D. O. Anderson and J. B. Moore, Linear Optimal Control, Prentice-Hall, 1990.*

Reference Books:

1. *S. P. Bhattacharya, H. Chapellat and L. H. Keel, Robust Control: The Parametric Approach, Prentice-Hall, PTR, NJ07458, 1995.*
2. *K. Zhou, J. C. Doyle and K. Glover, Robust and Optimal Control, Prentice-Hall, NJ07458, 1996.*
3. *J. Ackermann, Robust Control: Systems with Uncertain Physical Parameters, SpringerVerlag, London, 1993.*
4. *F. L. Lewis and V. L. Syrmos, Optimal Control, Second Edition, John Wiley and Sons, Inc. 1995.*

Course Outcomes:

Upon completing this course, the students would be able to,

1. design and implement system identification experiments.
2. use input-output experimental data for identification of mathematical dynamical models.
3. use singular value techniques to analyze the robustness of control systems.
4. incorporate frequency-domain-based robustness specifications into multivariable control system designs.
5. use H-infinity methods to design robust controllers.
6. explain the advantages and disadvantages of robust control relative to other control approaches.

ICHO16 – ELECTRONICS FOR SENSOR DESIGN

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

Course Learning Objectives:

1. To provide knowledge on the design of 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 provide knowledge on the 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, 2005.*
3. *Jacob Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications, Springer, 1993.*
4. *H.R. Taylor, Data Acquisition for Sensor Systems, Springer, 2010.*
5. *Manabendra Bhuyan, Intelligent Instrumentation: Principles and Applications, CRC Press Taylor & Francis Group, 2010*

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, 2003.*

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.