

Scheme of  
POSTGRADUATE DEGREE COURSE

**M.Tech. I to IV Semester**

**Control & Instrumentation**



(Effective from academic session: 2020-21)

Rajasthan Technical University, Kota  
Akelgarh, Rawatbhata Road, Kota-324010

**RAJASTHAN TECHNICAL UNIVERSITY**  
**M.Tech. (Control & Instrumentation)**  
**Teaching & Examination Scheme (Full Time) w.e.f. 2020-21**

**Semester I**

SN	Course Type	Course code	Course Name	Teaching Scheme			Marks			Credit
				L	T	P	I	E	T	
1.	PCC	1MCI1-01	Modern Control System	3	0	0	30	70	100	3
2.	PCC	1MCI1-02	Robotics and Automation	3	0	0	30	70	100	3
3.	PEC	1MCI2-11	Advanced Digital Signal Processing	3	0	0	30	70	100	3
		1MCI2-12	Artificial Intelligence in Industrial Automation							
		1MCI2-13	Optimization Techniques							
4.	PEC	1MCI2-14	Measurement Systems	3	0	0	30	70	100	3
		1MCI2-15	Industrial Automation Systems							
		1MCI2-16	Power System Dynamics and Control							
5.	MCC	1MCC3-21	Research Methodology and IPR	2	0	0	30	70	100	2
6.	PCC	1MCI1-06	Control and Computation Lab	0	0	4	60	40	100	2
7.	PCC	1MCI1-07	Modelling & Simulation Lab	0	0	4	60	40	100	2
8.	SODECA	1MCI5-00	Social Outreach Discipline & Extra Curriculum Activities					0	100	2
<b>Total</b>							<b>270</b>	<b>430</b>	<b>800</b>	<b>20</b>

## Semester II

SN	Course Type	Course Code	Course Name	Teaching Scheme			Marks			Credit
				L	T	P	I	E	T	
1.	PCC	2MCI1-01	Nonlinear Control Systems	3	0	0	30	70	100	3
2.	PCC	2MCI1-02	Advanced Biomedical Instrumentation	3	0	0	30	70	100	3
3.	PEC	2MCI2-11	Artificial Neural Networks	3	0	0	30	70	100	3
		2MCI2-12	Adaptive Control Systems							
		2MCI2-13	Large Scale Systems							
4.	PEC	2MCI2-14	Optimal Control theory	3	0	0	30	70	100	3
		2MCI2-15	Multi variable control systems							
		2MCI2-16	Micro-Electro-Mechanical-Systems							
5.	MCC	2MCC3-XX	Audit course-I	2	0	0				
6.	PCC	2MCI1-06	Advanced Instrumentation Lab	0	0	4	60	40	100	2
7.	PCC	2MCI1-07	Process Instrumentation & Automation Lab	0	0	4	60	40	100	2
8.	REW	2MCI4-50	Mini Project with seminar	2	0	4	60	40	100	2
9.	SODEC A	2MCI5-00	Social Outreach Discipline & Extra Curriculum Activities					0	100	2
<b>Total</b>									<b>800</b>	<b>20</b>

### Semester III

S.No	Course Type	Course Code	Course Name	Teaching Scheme			Marks			Credit
				L	T	P	I	E	T	
1.	PEC	3MCI2-11	Network Control Systems	3	0	0	30	70	100	3
2.		3MCI2-12	Digital Control System							
3.		3MCI2-13	Embedded Systems							
4.	MCC	3MCC3-XX	Audit course-II	2	0	0	0	0	0	P
5.	MCC	3MCC3-XX	Open Elective	3	0	0	30	70	100	3
6.	REW	3MCI4-60	Dissertation phase I:Industrial Project	0	0	20	240	160	400	10
<b>Total</b>								<b>300</b>	<b>600</b>	<b>16</b>

### Semester IV

SN	Course Type	Course code	Course Name	Teaching Scheme			Marks			Credit
				L	T	P	I	E	T	
1	REW	4MCI4-70	Dissertation phase-II	0	0	32	360	240	600	16
<b>Total</b>								<b>240</b>	<b>600</b>	<b>16</b>

## SEMESTER I

### 1MCI1-01: MODERN CONTROL SYSTEM

#### Syllabus:

CONTENTS	CONTACT HOURS
State variable analysis and design: State space model for continuous time linear system and discrete time linear system.	8
State space representation using phase variables and canonical variables, transfer function from state model, state model from transfer function, diagonalization Eigen values and eigen vector, solution of state equation.	10
Controllability, observability and reproducibility, controllable companion transformation, interpretation of controllability, observability criteria, duality, and output function controllability, input function observability.	8
State feedback control. State feedback and output feedback, pole assignment using state feedback and output feedback, reconstructing the state from available outputs.	6
Analysis of state equations, Control law design for full state feedback, Selection of pole locations for good design, Estimator design, Combined control law and Estimator loop transfer recovery, Integral control and robust tracking, Design of systems with pure time delay.	8
<b>Total</b>	<b>40</b>

#### REFERENCE/ TEXT BOOKS:

1. Richard C Dorf, Robert H. Bishop, "Modern Control Systems", 13th edition, Pearson, 2017.
2. S.K. Bhattacharya, "Control Systems Engineering", Pearson Education India, 2008.
3. Stanislaw H. Zak, "Systems and Control", 1st Edition, Oxford University Press Inc, 2002.
4. Raymond T. Stefani, Bahram Shahian, Late Clement J. Savant & Late Gene H. Hostetter, "Design of Feedback Control Systems" Fourth Edition, Oxford University Press India, 2006.
5. Norman S. Nise, "Control Systems Engg., Seventh Edition, Wiley, 2015
6. Benjamin C Kuo, "Automatic Control Systems" 6th Edition, Prentice Hall, 1994.

## 1MC11-02: ROBOTICS AND AUTOMATION

### Syllabus:

CONTENTS	CONTACT HOURS
Introduction: Definition, automation principles and strategies - scope of automation - socioeconomic consideration, low cost automation - Production concepts and automation strategies - Fixed Automation: Automated Flow lines, Methods of Work part Transport.	<b>6</b>
Transfer Mechanism - Continuous transfer, intermittent transfer - Indexing mechanism Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis.	<b>6</b>
Trajectory planning: Mathematical representation of Robots - Position and orientation – Homogeneous transformation-Variou joints- Representation using the DenavitHattenberg parameters -Degrees of freedom-Direct kinematics-Inverse kinematics- Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance- Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight line motion	<b>8</b>
Material handling: concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, rail guided vehicles, conveyor systems, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems(ASRS), Work-in-process Storage, Interfacing Handling and Storage with Manufacturing	<b>8</b>
Automated Inspection and Testing: Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods.	<b>6</b>
Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection Other applications: Application of Robots in welding, Spray painting, assembly operation, cleaning, robot for underwater applications. Gripper force analysis and gripper design for typical applications, design of multiple degrees of freedom, active and passive grippers - Factors influencing the choice of a robot, robot performance testing- Impact of robot on industry and society.	<b>6</b>
<b>Total</b>	<b>40</b>

## **REFERENCE/ TEXT BOOKS:**

1. AshitavaGhoshal, Robotics-Fundamental Concepts and Analysis', Oxford University Press, Sixth impression, 2010.
2. Richaerd D Klafter, Thomas Achmielewski and MickaelNegin, "Robotic Engineering – An integrated Approach" Prentice Hall India, New Delhi, 2001.
3. Deb S R and Deb S, —Robotics Technology and Flexible Automation, Tata McGraw Hill Education Pvt. Ltd, 2010.
4. Mikell P Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education, 2015.
5. Narcisco F. Macia, George J. Thaler, "Modeling and Control of Dynamic Systems", Cengage Learning; 1 edition, 2004.
6. Stephen J. Derby, "Design of Automatic Machinery", Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai, 2004.
7. J J Craig, —Introduction to Robotics: Mechanics and Control, Prentice Hall, 2004.
8. R M Murray, Z. Li and S SSastry, "A Mathematical Introduction to Robotic Manipulation", CRC Press, 1994.

## 1MCI2-11: ADVANCED DIGITAL SIGNAL PROCESSING

### Syllabus:

CONTENTS	CONTACT HOURS
The DFT: properties and efficient computation of DFT using FFT Algorithms.	8
Digital filter design and structures: design of FIR filters using windows and frequency sampling method, IIR filter design by impulse invariance, bilinear transformation.	8
Structures for FIR and IIR systems, Finite word length effects in FIR and IIR digital filters: coefficient quantization and round-off noise.	8
Multirate DSP: Decimators and Interpolators, Sampling rate conversion, multistage decimator and interpolator, poly phase representation, poly phase structures for Decimation and Interpolation filters, digital filter banks, quadrature mirror filter bank (QMF), perfect reconstruction (PR) systems. Application of multirate DSP in design of phase shifters and sub band coding of speech signals.	8
Introduction to wavelets: the wavelet transform and its relation to multirate filter banks, overview of wavelet applications.	8
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS:

1. A.V.Oppenheim, R.W.Schafer and J.R.Buck, "Discrete-Time Signal Processing", 2<sup>nd</sup> Edition, Pearson, 1999.
2. J.G.Proakis and D.G.Manolakis, "Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Pearson, 2009.
3. P.P.Vaidyanathan, "Multirate Systems and Filter Banks", Pearson, 1992.
4. V.M.Gadre and A.S.Abhyankar, "Multiresolution and Multirate Signal Processing", McGraw Hill Education, 2017.
5. Andreas Antoniou, "Digital Signal Processing: Signals, Systems, and Filters", 1<sup>st</sup> Edition, McGraw-Hill Education, 2005.
6. Andreas Antoniou, "Digital filters:", 2<sup>nd</sup> Edition, McGraw-Hill Education, 2000.



## 1MCI2-12: ARTIFICIAL INTELLIGENCE IN INDUSTRIAL AUTOMATION

### Syllabus:

CONTENTS	CONTACT HOURS
Introduction to Industrial Automation - Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Production Economics - Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.	8
Introduction to Artificial Intelligence -Introduction-Foundations of AI- History of AI Intelligent agents: Agents and Environment- Reactive agent- deliberative-goal-driven, utility driven and learning agents -Artificial Intelligence programming techniques.	8
Introduction to ML and DL Concepts Knowledge Representation and Reasoning - Ontologies-foundations of knowledge representation and reasoning-representing and reasoning about objects-relations- events actions- time- and space- predicate logic-situation calculus-description logics-reasoning with defaults,-reasoning about knowledge-sample applications- Representing Knowledge and reasoning in an Uncertain Domain- Bayes rule-bayesian networks-probabilistic inference sample applications- Planning: planning as search- partial order planning-construction and use of planning graphs.	8
Expert systems -Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge Acquisition – Meta knowledge, Heuristics. Typical expert systems – MYCIN, DART, XOON.	8
Industrial AI applications and Case studies - Applications of Industrial AI in Monitoring, optimization and control.AI applications in Industry Automation using -natural language processing-computer vision-speech recognition-computer vision	8
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS:

1. Rich and Knight, "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2014.
2. M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th edition, Pearson Education, 2009.
3. AnuradhaSrinivasaraghavan, Vincy Joseph "Machine Learning", Wiley, 2019
4. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 2nd Edition, Prentice Hall, 2003.
5. Rajiv Chopra, "Deep Learning", 1st edition, Khanna Publishing House, 2018.

## 1MCI2-13: OPTIMIZATION TECHNIQUES

### Syllabus:

CONTENTS	CONTACT HOURS
Introduction: Historical development, application to engineering problems, statement of optimization, classification of optimization, examples of optimization problems.	8
Linear Programming: Graphical method, simplex method, revised simplex method, Big-M method, 2- phase method, alternate optimal solutions, unbounded LPs, degeneracy and convergence, duality in linear programming, sensitivity analysis, dual simplex method, Transportation, assignment and other applications.	8
Non-Linear Programming: Unconstrained optimization techniques, direct search methods (Fibonacci method, golden section, quadrature and cubic interpolation) descent methods, constrained optimization, direct and indirect methods, optimization with calculus, kuhn-tucker conditions.	8
Dynamic Programming: Multistage decision process, principles of optimality, computational procedures in dynamic programming.	8
PID parameters optimization by using these techniques: Particle Swarm Optimization (PSO), Bacteria Foraging Algorithm (BFA), Genetic Algorithm (GA), and Ant colony optimization (ACO), Swarm Optimization Method(SMO), Artificial bee colony (ABC), grey wolf optimization (GWO), whale optimization algorithm (WOA), Sine Cosine algorithm (SCA) for 2 <sup>nd</sup> order and higher order stable & unstable systems.	8
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS:

1. Gerald J. Lieberman, Frederick S.Hillier, "Introduction to Operation Research", Seventh Edition, McGraw-Hill College,2001
2. A. Ravindran, Don T. Phillips, James J.Solberg, "OperationResearch:PrinciplesandPractice", SecondEdition, John Wiley & Sons,1987.
3. Research papers on PID parameter optimization

## 1MCI2-14: MEASUREMENT SYSTEMS

### Syllabus:

CONTENTS	CONTACT HOURS
Fundamental methods of measurements, concept of a generalized measurement system, types of measurements, Experimental engineering analysis. Static performance characteristics-static sensitivity, Linearity, Threshold Resolution, Hysteresis and Dead span and readability of scale.	8
Generalized static stiffness & input and output impedances. Dynamic performance characteristics, Generalized mathematical model of measurement system, operational transfer function.	8
Input types, order of instruments. Response of zero first and second order instruments to step, ramp and sinusoidal inputs. Transient and frequency response. Requirements of instrument transfer function for accurate measurement.	8
Numerical correction of dynamic data. Experimental determination of measurement system parameters. Loading effect under dynamic conditions. Accuracy and precision, types of errors, statistical analysis of data, Systematic (nonrandom) errors, Determination and minimization of systematic errors, Probability concept and distribution law, Accidental (random) errors, calculation of mean value and standard deviation from the measurements, confidence limits, conversion tables, Testing a distribution for normalcy, Propagation of error, significance test & Chi-square test, Contingency table.	8
Model of measurement systems, Models of resistive, capacitive piezo electric, optron, Seismic and Gyroscopic pickups. Dynamic studies of models.	8
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS:

1. David A. Bell, "Electronic Instrumentation and Measurements", Second Edition, Oxford University Press, 2006.
2. H.S. Kalsi, "Electronic Instrumentation", Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2010.
3. K. LalKishore, "Electronic Measurements And Instrumentation", Pearson Education India, 2009
4. Joseph J. Carr, "Elements of Electronic Instrumentation And Measurement", Pearson Education India; 3 edition, 2003.
5. J.W. Dally, "Instrumentation For Engineering Measurements", Pearson, 2003.
6. Richard S. Figliola, Donald E. Beasley, "Theory And Design For Mechanical Measurements" 6th edition, John Wiley & Sons, 2015.

## 1MCI2-15: INDUSTRIAL AUTOMATION SYSTEMS

### Syllabus:

CONTENTS	CONTACT HOURS
Automation in Manufacturing Industries Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, Advanced automation functions, Levels of automations, Automated flow lines and transfer mechanisms, Analysis of transfer lines without storage, Automated flow lines with storage buffers.	<b>8</b>
Material handling and identification technologies -Overview of material handling systems, Types of material handling equipment, Design of the system, Conveyor system, Automated guided vehicle system, Automated storage systems, Interfacing handling and storage with manufacturing, Overview of Automatic Identification Methods. Automated Manufacturing Systems-Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), FMS and its planning and implementation, Automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine.	<b>8</b>
Automation in Process Industries Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation. Programmable Logic Controller (PLC) - Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies.	<b>8</b>
Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.	<b>6</b>
Distributed Control System-Local Control Unit (LCU) architecture,LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS.Introduction to communication protocols-Profibus, Field bus, HART protocols.	<b>6</b>
Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS)	<b>4</b>
<b>Total</b>	<b>40</b>

## **REFERENCE/ TEXT BOOKS:**

1. M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
4. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw- Hill, New York, 2016.
5. Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson New International, 2013.
6. Lukas M.P, "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.
7. N. Viswanandham, Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", 1st Edition, 2009.

## 1MCI2-16: POWER SYSTEM DYNAMICS AND CONTROL

### Syllabus:

CONTENTS	CONTACT HOURS
Basic Concepts of dynamical systems and stability. Modelling of power system components for stability studies: generators, transmission lines, excitation and prime mover controllers, flexible AC transmission (FACTS) controllers.	12
Analysis of single machine and multi-machine systems. Small signal angle instability (low frequency oscillations): damping and synchronizing torque analysis, eigenvalue analysis. Mitigation using power system stabilizers and supplementary modulation control of FACTS devices.	12
Small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-measures. Transient Instability: Analysis using digital simulation and energy function method.	10
Transient stability controllers. Introduction to voltage Instability. Analysis of voltage Instability.	6
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS:

1. Arthur R. Bergen, "Power Systems Analysis", Second Edition, Pearson Education India, 2009.
2. K. R. Padiyar, "Power System Dynamics Stability and Control" 2<sup>nd</sup> Edition, BS Publications, 2008.
3. P.Kundur, "Power System Stability & Control", 1st Edition, McGrawHill, 2006.

## 1MCC3-21: Research Methodology and IPR

### Syllabus:

CONTENTS	CONTACT HOURS
Meaning of research problem, sources of research problem, criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	6
Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	4
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. 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.	8
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	4
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	6
<b>Total</b>	<b>28</b>

### REFERENCE/ TEXT BOOKS:

1. Stuart Melville and, WayneGoddard, "Researchmethodology: An introduction for science & engineering students" 2<sup>nd</sup> Edition, Juta& Company, 2004
2. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners" 5<sup>th</sup> edition, AGE Publications Ltd, 2019.
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
4. Mayall, "Industrial Design", McGraw Hill, 1992.
5. Niebel, "Product Design", McGraw Hill, 1974.
6. Asimov, "Introduction to Design", Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
8. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

## **1MCI1-06: CONTROL AND COMPUTATION LAB(LABVIEW)**

1. Programming and computation in LABVIEW.
2. Design of control systems and their simulation using LABVIEW software tool.
3. Implementation of pole placement algorithms for multivariable systems.
4. Observer design, stability computations, factorizations,
5. Solutions of Lyapunov and Ricatti equations, realizations, balancing.
6. Use of algorithms for multivariable time series modelling.
7. Design of ladder logic for various practical applications.
8. Execution of ladders using PLCs.
9. Experiment on Position and Velocity Control System.
10. Experiment on Adaptive Control System
11. Study of Analog and Digital Servo Systems.
12. Experiment on Non- Linear Control System



## 1MCI1-07: MODELLING AND SIMULATION LAB

Software required: - MATLAB

1. Design a lead compensator for a Temperature control system.
2. Design an estimator for a simple Pendulum and also design a reduced order estimator for the same.
3. Design a full order and reduced order compensator for satellite altitude control system.
4. Design an integral control law for a motor speed system.
5. Design a system with pure time delay on heat exchanger model.
6. Design a full order observer for specified pole locations on a satellite model.
7. Design a tracking control to follow a sinusoid for a disk drive servomechanism using MATLAB and SIMULINK.
8. Design a fuzzy logic controller for liquid level system.
9. Draw a phase portrait for a given nonlinear system.
10. Design an LQR based control system.
11. Design an observer controller for a given system.
12. Design a complete control system by applying any control strategy and comment on the results

## SEMESTER II

### 2MCII-01: NON LINEAR CONTROL SYSTEMS

Syllabus:

CONTENTS	CONTACT HOURS
INTRODUCTION: Nonlinear Control, Common Nonlinearities in Control systems Points of Differences in Linear And Nonlinear System Behavior. PHASE PLANE ANALYSIS: Phase Portraits, Singular Points, Construction of Phase Portraits, Method of Isoclines, Symmetry in Phase Portraits, Jump Resonance, Limit Cycles, Existence of Limit Cycles, Poincare-Bendixson Theorem .	10
DESCRIBING FUNCTIONS FUNDAMENTALS: Describing functions of Common Nonlinearities-computing describing functions, Describing functions of Common Nonlinearities- describing functions analysis of non-linear systems-stability analysis.	10
FUNDAMENTALS OF LYAPUNOV THEORY: Nonlinear Systems and Equilibrium points, Concepts of Stability Concepts of Stability, Linearization and Local Stability Lyapunov's Direct Method , Equilibrium Point Theorems, Krasovskii's method- variable gradient method	10
NONLINEAR CONTROL SYSTEM DESIGN: Feedback Linearization and the Canonical Form, Input State Linearization, Input-Output Linearization, Gain Scheduling, Sliding Control, Model Reference Adaptive Control.	10
<b>Total</b>	<b>40</b>

#### REFERENCE/ TEXT BOOKS:

1. Jean-Jacques E. Slotine, "Applied Nonlinear Control", Prentice Hall Englewood Cliffs, New Jersey 1991.
2. Vidyasagar.M, "Nonlinear System Analysis", Prentice Hall Englewood Cliffs, New Jersey 1978.
3. M. Gopal "Digital Control & State variable Methods", Tata McGraw Hill 2003.

## 2MCI1-02: ADVANCED BIOMEDICAL INSTRUMENTATION

### Syllabus:

CONTENTS	CONTACT HOURS
Recapitulation: Transducers, amplifiers and filters. ADC and DAC. Cells, Tissues, organs, Neurons, muscles. ECG, EEG and EMG signals.	8
The Cardio-pulmono-renal system: cardiovascular, pulmonary and renal systems. Their synergistic operations. Instrumentation for ECG and HRV, PPG, pulse oximetry and lung volumes.	8
Biomedical Signal Processing: ECG, HRV, EEG, EMG signals and their processing techniques. Classification, specificity and sensitivity.	8
Biomedical Image Processing: Origin and methods of image acquisitions, Ultrasound, X-ray, MRI, Nuclear imaging, Thermal Imaging and fused images. 3D imaging and modelling.	8
Safety and Ethics: Electric Safety, Medical Emergencies, First Aid, CPR, protocols and safety measures, ethics in biomedical instrumentation.	8
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS:

1. L. Cromwell, F. J. Weibell, and L. A. Pfeiffer, Biomedical Instrumentation and Measurements, Pearson Education-1990
2. J. J. Carr and J. M. Brown, Introduction to Biomedical Equipment Technology, 4th ed., Pearson Education, 2001
3. Biomedical Instrumentation Systems, Chatterjee, Cengage learning Pub, 2011
4. Aston, Principles of Biomedical Instrumentation & measurements, McGraw Hill publishing Company, 1990.
5. Kayvan Najarian, Biomedical Signal and Image Processing, CRC Press, 2016
6. Daniel A. Vallerio, Biomedical Ethics for Engineers: (Biomedical Engineering Series), Academic Press, 2007.

## 2MCI2-11: ARTIFICIAL NEURAL NETWORKS

### Syllabus:

CONTENTS	CONTACT HOURS
Introduction: Biological neurons and memory: Structure and function of a single neuron, artificial neural networks (ANN), typical applications of ANNs: classification, clustering, vector quantization, pattern recognition, function approximation, forecasting, control, optimization, basic approach of the working of ANN - training, learning and generalization.	10
Supervised Learning: single-layer networks, perceptron-linear separability, training algorithm, limitations; multi-layer networks-architecture, back propagation algorithm (BTA) and other training algorithms, applications. Adaptive multi-layer networks-architecture, training algorithms, recurrent networks, feed-forward networks, radial-basis-function (RBF) networks.	10
Unsupervised Learning: Winner-takes-all networks, hamming networks, maxnet, simple competitive learning, vector-quantization, counter propagation networks, adaptive resonance theory, Kohonen's Self-organizing Maps, principal component analysis.	10
Associated Models: Hopfield Networks, brain-in-a-box network, Boltzmann machine. Optimization Methods: Hopfield Networks for-TSP, solution of simultaneous linear equations, Iterated gradient descent, simulated annealing, genetic algorithm.	10
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS:

1. S. Shivanandam, S.Sumathi, "Introduction To Neural Network Using Matlab", Tata McGraw-Hill, 2006.
2. Jacek M. Zurada, "Introduction to Artificial Neural Systems", West Group, 1992.
3. B. YEGNANARAYANA, "ARTIFICIAL NEURAL NETWORKS"
4. RobertSchaloff, "Artificial Neural Network", TMH.
5. LaureneV.Fausett, "Fundamental of Neural Network Architecture and Application", Pearson.
6. JamesAFreeman, "Neural Networks: Algorithms, Applications, and Programming Techniques", Pearson, 1991.
7. Cristopher,M.Bhishop, "Neural N/W For Pattern Recognition", Oxford.
8. Raymond S.T. Lee, "Fuzzy Neuro Approach to Agent Application", NewAge, 2006.

## 2MCI2-12: ADAPTIVE CONTROL SYSTEMS

### Syllabus:

CONTENTS	CONTACT HOURS
Introduction, linear feedback, effects of process variations, adaptive schemes, the adaptive control problem.	8
Real time parameter estimation, Least squares and regression models, simulation of recursive estimation, Deterministic self-tuning regulators, indirect self tuning regulators, direct self tuning regulators.	8
Stochastic and Predictive self tuning regulators, Minimum variance and moving average controllers, Stochastic self tuning controllers, Linear quadratic STR.	8
Model reference adaptive systems: Introduction, The MIT rule, MRAS using Lyapunov theory, bounded input, bounded output stability, applications to adaptive control.	8
Properties of adaptive systems: Nonlinear dynamics, adaptation of a feed forward gain, Stochastic adaptive control, multi step decision problem, auto tuning techniques, Gain scheduling, Design of Gain- Scheduling controllers, Nonlinear transformations, application of gain scheduling.	8
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS

- Astrom, “Adaptive Control Techniques”, Pearson.
- Sastry, S. and Bodson,-“Adaptive Control ( Stability, Convergence and robustness)”,

## 2MCI2-13: LARGE SCALE SYSTEMS

### Syllabus:

<b>CONTENTS</b>	<b>CONTACT HOURS</b>
Introduction to Large Scale Systems. Principal Component based model reduction methods. Modelling of Large scale systems Aggregation Eigen value Assignment State Space (Time domain) order reduction methods	<b>10</b>
Transfer function (Frequency domain) model simplification, continued fraction expansion method, Time moment matching, Pade approximation stability based reduction methods	<b>10</b>
Error minimization methods order reduction of discrete time systems minimal realization Time scale analysis, Decoupling methods, fast-slow subsystem	<b>10</b>
State feedback design, Singular perturbations, controllers with accessible and in accessible states, design of optimal controllers, controllerreduction.	<b>10</b>
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS

- Large Scale System , Bandyopadhyay , IIT-Bombay

## 2MCI2-14: OPTIMAL CONTROL THEORY

### Syllabus:

CONTENTS	CONTACT HOURS
Maximization of functionals of a single and several functions using calculus of variations, Constrained extremals, Euler-Lagrange Equation, Necessary conditions for optimal control	10
Pontryagin's minimum principle and state inequality constraints, Minimum time problems, Minimum control effort problems, Linear quadratic regulator problems, Riccati Equation, Singular intervals in optimal control problems	10
The principle of optimality, Application of the principle of optimality to decision making, Dynamic programming applied to routing problems, Solving optimal control problems using dynamic programming	10
Discrete linear regulator problem, Hamilton -Jacobi -Bellman Equation, Numerical Techniques to determine optimal trajectories.	10
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS

- Optimal Control Theory: An Introduction,,Dover Publications; 1st edition- 2004.
- Introduction to Optimal Control Theory by Macki, Jack, Strauss, Aaron
- Optimal Control System, Naidu ,CRCPress.

## 2MCI2-15: MULTI-VARIABLE CONTROL SYSTEMS

### Syllabus:

<b>CONTENTS</b>	<b>CONTACT HOURS</b>
The state observability problem, state controllability, Discrete time systems: Reachability and constructability, some examples to discuss the above fundamentals,	<b>10</b>
Representation of noncontrollable realizations, minimal realizations, The Popov-Belevitch-Hautus test for controllability and observability.	<b>10</b>
Uncontrollable and controllable modes and eigen values. Classification of linear controllable systems: Autonomous systems, discrete and periodic systems, stabilization controllability and observability of linear autonomous systems.	<b>10</b>
Controllability and observability conditions of linear autonomous systems, observing the state of a linear system.	<b>10</b>
<b>Total</b>	<b>40</b>

### REFERENCE/ TEXT BOOKS

- Systems & Control, Zak, Oxford
- Discrete Time Control System 2<sup>nd</sup> Edition, Ogata, Prentice Hall
- Design Feedback Control Systems 4e, Stefani, Oxford
- Control Systems Engg., Nise, Oxford
- Linear and Nonlinear Multivariable Feedback Control, Oleg N. Gasparyan, Wiley



## 2MCI2-16: MICRO-ELECTRO-MECHANICAL-SYSTEMS (MEMS)

<b>CONTENTS</b>	<b>CONTACT HOURS</b>
Micro electro mechanical system (MEMS) origins.MEMS impetus/ motivation. Material for MEMS.	<b>10</b>
The toolbox: processes for micro machining. MEMS fabrication technologies. Fundamentals MEMS device physics: Actuation.	<b>10</b>
Fundamental MEMS devices: The cantilever beam. Microwave MEMS applications: MEM switch design considerations.	<b>10</b>
The micro-machined transmission line.MEMS-based microwave circuit and system.	<b>10</b>
<b>Total</b>	<b>40</b>

### **REFERENCE/ TEXT BOOKS:**

1. Max J. Madou: "Fundamentals of Micro Fabrication", The science of miniaturization-, Nanogen corporation, USA, CRCpress, 2002.
2. Sergey Edward Lyshevski, "Nano-And Micro Electro Mechanical Systems", 2<sup>nd</sup> Edition, CRC press, Boca RatonLondon, 2002.
3. Sherifsedky: "Integrated MEMS"- Artech House, BostonLondon.
4. N. Maluf,"Introduction To Micro Mechanical Systems Engineering", 2<sup>nd</sup> Edition, ArtechHouse, 2004.
5. Tai – Ran Hsu,"Mems and Micro Systems: Design and Manufacture" Tata McGrawHill 2002.

## 2MCI1-06: ADVANCED INSTRUMENTATION LAB

List of Experiments:

Rotor-1

These experiments are to be performed on bread-board and then design on PCB.

1. Design second order high pass filters of 0.05 Hz, .5 Hz., 5 Hz and 10 Hz, with variable gain upto 5. Plot the Bode Plot for each using an audio frequency generator and oscilloscope.
2. Design second order low pass filters of 15 Hz, 35 Hz., and 100 Hz, with variable gain upto 5. Plot the Bode Plot for each using an audio frequency generator and oscilloscope.
3. Design a notch filter having a notch at power frequency of 50 Hz with variable gain upto 3. Plot the Bode plot using an audio frequency generator and oscilloscope and discuss the effect of gain on CMRR and stability.
4. Design a differential amplifier for gain of 100, 250, 500 and 1000. Try to optimize the CMRR.

Rotor-2

5. Combine all the components of previous rotor and test the CMRR, GB characteristics and Bode Plot.
6. Obtain a greyscale image using the thermal imager and segment the areas having similar temperature.
7. Record an ECG signal using the RMS-ECG and calculate the cardiac axis, P- axis and T- axis with onscreen observations.
8. Download an X-ray image of chest from the internet and identify the organs and bones.

Rotor-3: Design a data-acquisition system with 2-4-8 channel and programmable sampling frequency. (Running parallel with previous rotors).

## **2MCII-07: PROCESS INSTRUMENTATION & AUTOMATION LAB**

### List of Experiments

1. Design and development of two wire temperature Transmitter
2. Design and development of IOT based transmitter
3. Cascade and feedback controller design for real time process trainer
4. Feed forward and ratio controller design for real time process trainer
5. Development of combinational and sequential logic application using minimum PLC languages
6. Development of Ladder logic programme for control of real time processes.
7. Development of SCADA for a control of real time processes.
8. Study of HART and Field bus protocol.
9. P&I diagram development using simulation software for complex processes
10. Study of Distributed Control System and different instruction sets.
11. Development of Cascade, ratio and feedback controller using DCS simulation software
12. Development of HMI and annunciator circuits using DCS simulation software

Upon completion of the course students will

1. Have exposure in design of different controller suitable for real time processes.
2. Have adequate programming skills using PLC, DCS and SCADA.
3. Have knowledge of Ladder Logic programming.

## SEMESTER III

### 3MCI2-11: NETWORK CONTROL SYSTEMS

#### Syllabus:

CONTENTS	CONTACT HOURS
Stochastic process – Introduction to random variables, Expectations, Moments, stationary and non- stationary process.	10
Network models – Stochastic model, communication network constraints, packet delay, packet loss, uncertain observation, Markov chain based model.	10
Estimation of networked control system – Observer for networked system, Kalman filter. Control strategies – Output feedback control, Predictive control.	10
Introduction to graph theory, Simulation of network control system, Application of network control system.	10
<b>Total</b>	<b>40</b>

#### REFERENCE/ TEXT BOOKS:

- J. Medhi, “Stochastic Processes”, 3rd Edition, New Age Science, 2009.
- Jagannathan Sarangapani, Hao Xu, “Optimal Networked Control Systems with MATLAB”, 1st Edition, CRC press, Taylor and Francis group, 2016.
- Xia Y., Fu M., Liu GP., “Analysis and Synthesis of Networked Control System, Lecture Notes in Control and Information Sciences”, Springer-Verlag Berlin Heidelberg, 2011.
- Anderson, B.D.O. and Moore J.B., “Optimal Filtering”, Prentice-Hall, Englewood Cliffs, New Jersey, 1979.
- K You, N Xiao, L Xie, “Analysis and Design of Networked Control System, Communications and Control Engineering”, Springer London Heidelberg New York Dordrecht, 2015.
- Srikant, Rayadurgam, Lei Ying, “Communication networks: an optimization, control, and stochastic networks perspective. Cambridge University Press, 2013.

### 3MCI2-12: DIGITAL CONTROL SYSTEM

**Syllabus:**

CONTENTS	CONTACT HOURS
Basic system concepts and classification of digital control system, feedback systems and digital control, sampling and reconstruction of signals, computer interfacing, discrete time system response, convolution of sequences.	<b>6</b>
Z-transform, pulse transfer function, pulse transfer function of the zero order hold, signal- flow graph method applied to digital systems.	<b>4</b>
State variable technique. state equations and state transition equation of discrete-data system, state equation of digital system with sample and hold, state equation of digital transition equation of digital systems & for digital time invariant systems.	<b>8</b>
Stability of digital control systems. Definitions of stability, stability tests of digital systems. Digital simulation-digital model with sample and hold.	<b>4</b>
Comparison of time responses of continuous data and digital control system, correlation between time response and root locations in the s-plane and the z-plane, root loci for digital control system, steady- state error analysis of digital control system, frequency domain analysis, the Nyquist plot, bode diagram, gain margin, phase margin. Theorems on controllability and observability (time varying & time invariant systems) relationship between controllability, observability and transfer functions.	<b>8</b>
Design of digital control system: Cascade & feedback compensation with continuous data controllers, digital controller, Design of digital control system with digital controller. The digital PID controller, controller through the bilinear transformation, design of digital control system with dead beat response. Introduction to PLC.	<b>8</b>
<b>Total</b>	<b>40</b>

**REFERENCE/ TEXT BOOKS:**

- Benjamin C. Kuo, “Digital Control Systems”, Ed. 2, Oxford University Press, 1999.
- K. Ogata, “Discrete-time Control Systems”, Ed. 2, Prentice-Hall, 1995.
- Modern Digital Control Systems, Raymond G. Jacquot, MarcelDekker
- Digital Control System Analysis and Design, Charles L. Phillips, H. TroyNagle
- Digital Control by Kannan M. Moudgalya, wiley

### 3MCI2-13: EMBEDDED SYSTEMS

#### Syllabus:

CONTENTS	CONTACT HOURS
Embedded system architecture and classifications, challenges, choice and selection of microcontrollers for embedded systems design.	8
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.	12
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, and resource allocation, interrupt handling.	14
Other issues of RTOS. Examples of RTOS. Working with TI-RTOS with TIVA ARM Cortex embedded controllers	6
<b>Total</b>	<b>40</b>

#### REFERENCE/ TEXT BOOKS:

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

## ANNEXURE II

### (Dissertation)

#### 3MCI4-60: Dissertation Phase – I

#### 3MCI4-70: Dissertation Phase – II

##### Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following

- Relevance to social needs of society
- Relevance to value addition to existing technologies & advancement in the institute
- Relevance to industry.
- Problems of national importance
- Research and development in various domains

The student should complete the following:

- Literature survey
- Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:

- Experimental verification / Proof of concept.
- Design, fabrication, testing of Communication System.
- The viva-voce examination will be based on the above report and work.

##### Guidelines for Dissertation Phase – I and II

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in research lab/ industry allotted through department's/T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. There referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.

- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with the university appointed examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work.