MASTER OF TECHNOLOGY
IN
CONTROL AND AUTOMATATION
Common
CURRICULUM & SYLLABUS

The proposed curriculum for all core Engineering subjects like CSE, IT, ECE, EE, C&A, C&I:

1st Semester

Theory:

Sl. No.	CODE	Paper	Contacts periods Per weeks			Total Contact Hrs	Credits
			L	T	P		
1	EAM301	Advanced Engg. Math	3	1	0	4	4
2	CAM101	Compulsory	3	1	0	4	4
3	CAM102	Compulsory	4	0	0	4	4
4	CAM103	Elective I	4	0	0	4	4
5	CAM104	Elective II	4	0	0	4	4
		Total of Theory				20	20

Practical / Sessional:

Sl. No.	CODE	Paper	Contacts periods Per weeks			Total Contact Hrs	Credits
			L	T	P		
1	CAM191	Laboratory I	0	0	3	3	2
2	CAM192	Laboratory II	0	0	3	3	2
3	CAM193	Seminar I	0	0	3	3	2
		Total of Practical / Sessional				9	6
TOTAL OF SEMESTER:			18	02	09	29	26

2nd Semester

Theory:

Sl. No.	CODE	Paper	Contacts periods Per weeks			Total Contact Hrs	Credits
			L	T	P		
1	CAM201	Compulsory	3	1	0	4	4
2	CAM202	Compulsory	4	0	0	4	4
3	CAM203	Compulsory	3	1	0	4	4
4	CAM204	Elective III	4	0	0	4	4
5	CAM205	Elective IV	4	0	0	4	4
		Total of Theory				20	20

Practical / Sessional:

Sl. No.	CODE	Paper	Contacts periods Per weeks			Total Contact Hrs	Credits
			L	T	P		
1	CAM291	Laboratory III	0	0	3	3	2
2	CAM291	Laboratory IV	0	0	3	3	2
3	CAM293	Seminar II	0	0	3	3	2
		Total of Practical / Sessional				9	6
TOTAL OF SEMESTER:			18	02	09	29	26

3rd Semester

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Theory:

Sl. No.	CODE	Paper	Contacts periods Per weeks			Total Contact Hrs	Credits
			L	T	P		
1	EMM301	Introduction to Management	4	0	0	4	4
2	CAM301	Elective V	4	0	0	4	4
		Total of Theory				8	8

Sessional:

Sl. No.	CODE	Paper	Contacts periods Per weeks			Total Contact Hrs	Credits
			L	T	P		
1	CAM391	Pre-submission Defense of Dissertation	0	0	0	0	4
2	CAM392	Dissertation (Part-I)	0	0	0	20	10
		Total of Sessional				20	14
TOTAL OF SEMESTER:						28	22

4th Sem

Sessional:

Sl. No.	CODE	Paper	Contacts periods Per weeks			Total	Credits
1	CAM491	Dissertation (Completion)	0	0	0	24	14
2	CAM492	Post-submission Defense of Dissertation	0	0	0	0	8
	CAM493	Comprehensive Viva-Voce	0	0	0	0	4
						24	26
TOTAL OF SEMESTER:						24	26

Total Credits: 26 + 30 + 22 + 22 = 100

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FIRST SEMESTER:

A. THEORY				
SL. NO.	**CODE**	**SUBJECT**	**NO. OF PAPERS**	**MARKS**
1	EMM101	Advanced Engineering Mathematics	1	100
2	CAM101	Control Systems – I	1	100
3	CAM102	Industrial Automation and Control	1	100
4	CAM103	Elective I (Any one) a) Electrical Sensors and Transducers b) Modeling and Simulation of Dynamic Systems c) Electronic devices and Systems	1	100
5	CAM104	Elective II (Any one) a) Soft Computing Techniques b) Digital Signal Processing c) Automated Test and Measurement	1	100
		TOTAL OF THEORY		500
B. PRACTICAL / SESSIONAL				
6	CAM191	Laboratory I - Control System Laboratory	1	100
7	CAM192	Laboratory II - Automation Laboratory	1	100
8	CAM181	Seminar I	1	100
		TOTAL OF PRACTICAL / SESSIONAL		300
		TOTAL OF SEMESTER		800

SECOND SEMESTER:

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A. THEORY				
SL. NO.	**CODE**	**SUBJECT**	**NO. OF PAPERS**	**MARKS**
1	CAM201	Control Systems – II	1	100
2	CAM202	Process Instrumentation and Control	1	100
3	CAM203	Power Electronics	1	100
4	CAM204	Elective III (Any one) a) Real time System b) Electric Drives c) Digital Control System	1	100
5	CAM205	Elective IV (Any one) a) System Identification and Estimation b) Power System Operation and Control c) Remote Sensing and Control	1	100
			TOTAL OF THEORY	500
B. PRACTICAL / SESSIONAL				
6	CAM291	Laboratory III -Process Instrumentation Laboratory	1	100
7	CAM292	Laboratory IV - Power Electronics and Drives Laboratory	1	100
8	CAM281	Seminar II	1	100
			TOTAL OF PRACTICAL / SESSIONAL	300
			TOTAL OF SEMESTER	800

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THIRD SEMESTER:

A. THEORY				
SL. NO.	**CODE**	**SUBJECT**	**NO. OF PAPERS**	**MARKS**
1	EMAN301	Introduction to Management	1	100
2	CAM301	Elective V (Any one) a) Robotics b) Biomedical Instrumentation c) Intelligent Control	1	100
			TOTAL OF THEORY	200

B. SESSIONAL				
3	CAM382	Pre-submission Defense of Dissertation	1	100
4	CAM381	Dissertation (part I)	1	100
			TOTAL OF SESSIONAL	200
			TOTAL OF SEMESTER	400

FOURTH SEMESTER:

SESSIONAL				
1	CAM482	Post submission defense of dissertation	1	100
2	CAM481	Dissertation (Completion)	1	300
3	CAM483	Comprehensive Viva-Voce	1	100
			TOTAL OF SESSIONAL	500
			TOTAL OF SEMESTER	500

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Advanced Engineering Mathematics

EAM101
Contact: 3L+1T
Credit: 4

Complex Variables:
Review of complex variables, Conformal mapping & transformations, Function of complex variables, Pole and singularity, Integration with respect to complex argument, Residues and basic theorems on residues.

Numerical Analysis:
Introduction, Interpolation formulae, Difference equation, Roots of equations,
Solution of simultaneous linear and non-linear equations, Solution techniques for ODE and PDE, Introduction to stabilty, Matrix eigen value and eigen vector problems.

Optimization Technique:
Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Elements of calculus variation, Constrained Optimization, Lagrange multipliers, Gradient method, Dynamic programming.

Linear Algebra:
Vector space, Linear dependence of vectors, basis, linear transformations, inner product space, rank and inverse of a matrix, solution of algebraic equations, consistency conditions, Eigen values and eigen vectors, Hermitian and Skew Hermitian matrices.

Books:

1. John B. Conway, Functions of one complex variable, Springer International.
2. James Ward Brown & Ruel V. Churchill, Complex variable and application., Mc Graw Hill International edition .
3. John H. Mathews, Numerical Methods for Mathematics , science and Engineering, PHI
4. D.C. Sanyal and K. Das, A text Book of Numeriacl analysis, U.N. Dhar & Sons Pvt. Ltd.
5. S.S.Rao,, Optimisation theory and application, Wiely Eastern limited

Hoffman & Kunze. R, Linear Algebra, PHI

Control System – I

CAM 101
Contact: 3L+1T
Credit: 4

Modelling and Analysis of LTI Systems:
Modelling of physical Systems. Hydraulic and pneumatic actuators. Inverted pendulum system. Linearisation, linearising continuous time non-liear models.
Time domain solution. Error constants. Effects of adding poles and zeros to transfer function. Design specifications and performance indices. Motion control systems, gear drives and sensors. Servo system with velocity feedback. Transportation lags. Approximation of time-delay functions. Sensitivity of control systems to parameter variations. Effects of disturbance signals. Disturbance rejection.

Analysis in state-space:
A perspective on state-space design. State variables. State models for physical systems. SISO and MIMO systems. Solution of state equations. Transfer function. Eigenvalues and eigenvectors. Jacobian linearization technique. State transformations and diagonalisation. Transformation to phase-variable canonical form. Controllability and observability. Duality property. Stability.

Introduction to Discrete-time Systems:
Basic elements of discrete-time control system. Z-transform and properties. Inverse Z-transform. Difference equation and its solution by Z-transform method. Z-transfer function. State diagram of digital systems. Time delay. Direct, cascade and parallel decomposition of Z-transfer functions.

Feedback control design:
Continuous control design. Proportional, derivative and integral control action. PID controller tuning rules. Ziegler-Nichols method. Two degree of freedom control systems.
Compensator design using Bode diagram in frequency response approach. Lag, Lead, Lag-lead compensator.
Control law design for full state feedback by pole placement. Full order observer system. Observer based state feedback. Separation principal.

Reference Books:

1. Ogata, K – Modern Control Engineering, PHI Learning
2. Kuo, B.C. – Automation Control Systems, Prentice Hall
3. Roy Choudhury, D – Modern Control Engineering, Prentice Hall
4. Nagrath, J. J. Gopal, M – Control System Engineering, New Age Pub.
5. Schulz, D.G. and Melsa, . L. – State Functions and Linear Control Systems, McGraw-Hill.

Industrial Automation and Control

CAM 102
Contact: 4L
Credit: 4

Overview: Structure & components Industrial Automation systems. Architectural levels of Industrial controls.

Actuators & sensors: Servomotors, Stepper motors, Process I/O systems. Local & remote I/O systems.

Controllers: Different types of controllers, Single loop and Multiloop controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct Digital Controllers, Software implementation of Multiloop Controllers. Distributed Control Systems.

Sequence Control: Programmable Logic Controllers, Relay Ladder Logic, Programming.

Supervisory Controllers: Functionally of Supervisory Control Level, Process Optimization, Recipe Management Material. Tracking. Man-machine interfaces.

Process Operation Management Systems: Overview of process operation management systems, order, inventory management, process scheduling, quality management.

Industrial Communication Systems: Characteristic features of industrial networks. Low level networks and their features, Field bus architecture. Performance aspects of Industrial Automation Systems.

Reference Books:

1. Webb J.W-Programmable controllers: Principle and Applications, PHI New Delhi
2. Parr A –Programmable Controllers :An Engineers' Guide, Newnes, Butterworth-HeinnemanLtd-1993.
3. Liptak B.G (ED)-Process Control H andbook,vol-2 Chilton book Co.
4. Noltinc - Handbook for Instrumentation Engineers.
5. Bollinger J.G and Duffie N.A-Computer control of machines and processes, Reading M A, Addison-Wesley, 1988.

Electrical Sensors and Transducers

CAM 103(a)

Contact: 4L
Credit: 4

Introduction:
Differences between devices used for measurement of various parameters – sensors, transducers, probes, etc. Principle of physical and chemical transduction, sensor classification – thin / thick film, active / passive, electrical / mechanical / optical, etc.
Static and dynamic performance characteristics of analogue and digital transducers. Specifications. Determination of sensor characteristics, characterization and calibration.

Electrical Transducers:
Principles, design considerations for better performance characteristics, output circuits and interfacing techniques, and applications of following transducers.
(a) Variable resistance type – Potentiometers, strain gauges, RTD, thermistors, hotwire anemometers. (b) Variable inductance type – self and mutual inductance, pulse transducer. (c) Variable capacitance transducers. (d) Special Transducers: Semiconductor temperature sensors, thermo-electric sensors, piezoelectric sensors, magnetostrictive sensors, polymer like polypyrrole, smart sensors. (e) Electromechanical Transducers: Electrodynamic, eddy current, force balance transducers. Basics of MEMs devices.

Power System Transducers:
Analogue and digital transducers for measurement of voltage, current, power factor, frequency, power – active and reactive. RTU for tariff calculation.

Analogue Signal Conditioning techniques:
Bridge amplifier, carrier amplifiers, charge amplifiers and impedance converters, modulation - demodulation, dynamic compensation, linearization, multiplexing and demultiplexing.

Digital Interfacing techniques:
Digital Interfacing techniques. Interfaces, processors, code converters, linearizers.

Signal Transmission:
Transmitters, V-I, I-V and V-f converters. Single transmission .Cable transmission of analog and digital signal, fibre optic signal transmission, radio, telemetry, pneumatic transmission.

Signal Display / Recording systems:
Signal Display/Recording systems. Graphic display systems, storage oscilloscope, recorders-ink, thermal, UV, Data loggers.

Reference Books

1. Doeblin, E.O. – Measurement Systems: Application and Design, Mc Graw Hill International.
2. Patranabis, D – Sensors and Transducers, Wheeler Pub., New Delhi.
3. Murthy, D.V.S., Transducers and Instrumentation, PHI, New Delhi.
4. Swobada, G. – Telecontrol: Methods and Applications of Telemetry and Remote Control. Van Nostrand.
5. Newbert, H. K. – Instrument Transducers, Oxford University Press.

Modeling and Simulation of Dynamic Systems

CAM 103 (b)
Contact: 4L

Credit: 4

Module 1:
Introduction, State space representation of systems of different kind. Simulation of the state model. Describing equations and different kinds of models. Eigen values and vectors, Similarity X'formation, invariants. Stability, controllability, observability, Leverrier's algorithm. Linearization of nonlinear systems

Module 2:
Theorem on feedback control, pole placement controller. Full order and reduced order observer design. Theory of industrial regulation, feed forward control. Application - motor speed control with disturbance rejection.

Module 3:
Heat flow in one dimension, finite element method. Modeling and simulation through bond graphs. Qualitative reasoning: M & S with Incomplete Knowledge.

Module 4:
Sensor modeling: Lumped parameter and distributed parameter models, Thick and thin film models. Numerical modeling techniques, model equations, application of Finite Element method.

Different effects on modeling - temperature, radiation, mechanical, chemical, magnetic, electrical (e.g. capacitive, resistive, piezo-resistive, frequency, etc.).

Examples of modeling: micro-modeling of photodiodes, magnetic, capacitive, mechanical sensors.

Reference Books:

1. D M Wiberg State Space and Linear Systems Schaum's Outline Series McGraw Hill 1971
2. W B J Zimmerman Process Modeling and Simulation with Finite Element Methods Univ. of Sheffield UK 2004
3. Amalendu Mukherjee and Ranjit Karmakar Modeling and Simulation of Engineering Systems through Bond Graphs Narosa New Delhi 1999
4. Benjamin Kuiper Qualitative reasoning: Modeling and Simulation with Incomplete Knowledge MIT Press Cambridge Mass 1994
5. Thomas Kailath Linear Systems Prentice Hall 1980
6. Robert D. Strum and Donald E. Kirk Contemporary Linear Systems Using Matlab Thomson Learning1999
7. M Gopal Modern Control System Theory Wiley Eastern 1984
8. M Gopal Digital Control Engineering Wiley Eastern 1988
9. K Ogata Modern Control Engineering 4th edition Prentice Hall 2002
10. B C Kuo Automatic Control Systems 7th Edition Prentice Hall 1995
11. Patranabis, D.- Sensors and Transducers. 2nd edition, PHI, New Delhi,
12. Ghosh, M. K. et al (ed) - Trends in.....
13. Learning MATLAB and Simulink Mathworks
14. Grandke, T. and Ko, W.H.(ed) - Sensors: Fundamentals and General Aspects. Vol I of Sensors: A Comprehensive Survey. VCH, Germany, 1989

Electronic Devices and Systems

CAM 103 (c)
Contact: 4L

Credit: 4

Special Operational Amplifiers: High voltage/high current, Chopper and chopper stabilized amplifiers, Instrumentation amplifier, Isolation amplifier
Nonlinear Function Circuits: Limiter, Log/anti-log, Multiplier/divider, Peak detector, Comparator, True RMS/DC converter, Square wave oscillators
Timing and Counting Circuits: Digital counters, Shift register, Analog and digital timers, Frequency counters, PLA and PLD applications.
Sinusoidal and Relaxation Oscillators: Phase shift, ring, Wien-bridge, Tuned, Quadrature oscillator, Crystal oscillator and clock circuits, Voltage controlled oscillators – sine, Square and triangle, Frequency synthesizers.
Frequency-to-voltage Converters: Diode pump integrator, Frequency and RPM transducers. Phase and phase/frequency comparators – analog and digital
Phase Locked Loops: Linear model, Loop response, Applications of PLL.
Power Semiconductor Devices: Special thyristors (GTO, LASCR, TRIACs etc) BJT power MOS, IGBT, MCT, Power semiconductor control circuits, SMPS, UPS, Inverters, Switching mode amplifier
Optoelectronic Devices: Photo diode/transistor, LDR, LED and LCD displays, Opto-coupler, Optointerrupter, High speed detectors – PIN and avalanche photo diodes, Fibre optic data link
Active Filters: Types, Filter approximations – Butterworth and chebyshev, Filter realisations, Frequency and impedance scalings, Filter transformations, Sensitivity, Switched capacitor circuit, Data conversion and acquisition – A/D and D/A converters, DVM/DMM, Quantisation noise in ADCs, Selection of ADCs, Sample and hold circuit, Multiplexer and demultiplexer, Programmable gain amplifier, Microprocessor interfacing techniques

Suggested Readings:
1. B. S. Sende, *Introduction to System Design Using Integrated Circuits*, New Delhi: New Age International (P).
2. F. C. Fitchen, *Integrated Circuits and Systems*, New York: Van Nostrand.
3. Seymous, *Electronic Devices and Components*.

Soft Computing Techniques

CAM 104 (a)
Contact: 4L
Credit: 4

Module 1
Introduction to Soft Computing, components of soft computing, traditional computing and drawbacks, advantages of soft computing techniques.

Module 2
Introduction to fuzzy logic: definition, general idea and importance in practical life. Fuzzy set theory: concept of fuzzy set, membership functions, comparison of fuzzy set and classical set. Operations on fuzzy sets, properties of standard operations, T norm and S norm, Extension principle and application. Height of fuzzy set, core of fuzzy set, support of fuzzy set, normal fuzzy set, normalization of fuzzy set, level set, α cut and strong α cut of fuzzy set, concentration and dilation of fuzzy sets, fuzzy singleton, crossover points.

Fuzzy relation: fundamentals of fuzzy relations, operations on fuzzy relations, composition of fuzzy relations, fuzzy reasoning, fuzzy relation inferences, compositional rule of inference, fuzzification. Fuzzy methods in control theory: Introduction to fuzzy logic controller, types of fuzzy logic controllers, basic structure of fuzzy knowledge based controllers, defuzzification methods, applications of fuzzy logic control.

Module 3
Introduction to artificial neural networks, artificial neuron model, types of activation functions. Learning in neural networks, feed forward and feedback neural networks, backpropagation training algorithm, Hopfield network, Boltzman machine. Self organizing map, learning vector quantization algorithm.

Module 4
Basic concept of genetic algorithm, comparison of GA and traditional techniques, objective function and fitness function, crossover, mutation, GA search, applications of GA.

Reference Book:

1. Klir, G.J. & Yuan,B.- Fuzzy sets and Fuzzy logic, theory and applications, Prentice Hall of India Private Limited.
2. M. Ganesh - Introduction to fuzzy sets and fuzzy logic, PHI.
3. N. P. Padhy – Artificial intelligence and intelligent systems, Oxford
4. Timothy J. Ross – Fuzzy logic with engineering applications, Wiley.
5. Nie and Linkens,- Fuzzy Neural Control-Principles, Algorithms and Application, PHI
6. J.S.R. Jang, C.T. Sun, E. Mizutani - Neuro-fuzzy and soft computing, PHI.
7. Kosco, B.-Neural Networks and Fuzzy System.PH
8. Haykin- Neural Network; A Comprehensive Foundation, PHI
9. Rajasekaran and Pai – Neural Networks , Fuzzy Logic and Genetic algorithms: Synthesis and Application, PHI.
10. Goldberg- Genetic Algorithms, Pearson.

Digital Signal Processing

CAM 104(b)
Contact: 4L
Credit: 4

Introduction to Signal Processing: Review of Laplace transform, Z transform, Fourier transform. Discrete Fourier transform, Fast Fourier transform, Algorithms and complexity, Introduction to linear optimal filtering
Digital Filter: Definition and anatomy of a digital filter, Frequency domain description of signals and systems, Typical application of digital filters, Replacing analog filters with digital filters, Filter categories: recursive and non-recursive
Digital Filter Structures: The direct form I and II structures, Cascade combination of second order sections, Parallel combination of second order sections, Linear- phase FIR filter structures, Frequency sampling structure for the FIR filter
Effect of Word Length: Round off error, Truncation error, Quantization error, Limit cycle
Introduction to DSP Hardware: Application of DSP in control system and instrumentation

Suggested Readings:
1. S. K. Mitra, *Digital Signal Processing*, PHI
2. J. C. Proakis, and D. G. Maniolakis, *Digital Signal Processing*: *Principles, Algorithms and Applications*, Prentice Hall.
3. Oppenheim, and R. W. Shaffer, *Discrete Time Signal Processing*, Prentice Hall, 1992.
4. J. Johnson, *Digital Signal Processing*, Prentice Hall.
5. B. Venkata Ramani, and M. Bhaskar, *Digital Signal Processors*, New Delhi: Tata McGraw Hill.

Automated Test and Measurement

CAM 104 (c)
Contact: 4L
Credit: 4

Measurement automation, Comparison with classical measurement and microprocessor based measurement, Measured data base and data base management, Real time signals, Calculated signals
Digital signal processing, Processed signals, Data flow and graphical programming techniques, Virtual instrumentation (VI), Advantages, VIs and Sub VIs
Data acquisition methods, DAQ hardware, Instrumentation buses, IEEE 488.1 and IEEE 488.2, Serial interfacing-RS 232C, RS 422, RS 423, RS 485, CAMAC, VXI, SCXI, PXI
Industrial drives and interface, Sensors and transducers, Interfacing signal conditioning, Signal analysis techniques, Networking methods and their applications in instrumentation

Suggested Readings:
1. N. Mathivanan, *PC-based Instrumentation-Concepts and Practice*, Prentice-Hall.
2. M, Chidambaram, *Computer Control of Processes*, Narosa Publishing House.
3. B. G. Liptak, *Instrumentation Engineers Handbook*, Philadelphia: Chilton Book Company.

Control Systems – II

CAM 201
Contact: 3L+1T
Credit: 4
Non linear system:
Classification and types of non-linearity. Phenomena peculiar to non-linear systems. Methods of analysis. Linearization based on Taylor's series expansion. Jacobian Linearization.
Phase trajectory and its construction. Phase-plane analysis of linear and non-linear sustems. Existence of limit cycles. Describing function of typical non-linearities. Stability analysis by DF method. Introduction to DIDF. Popov's circle criterion. Stability analysis by Lyapunov's indirect and direct methods, Lypunov's theorem.

Introduction to Chaotic System.

Optimal Control:
Linear optimal control with quadratic performance index , Selection of performance measure. State and output regulators. Optimal state regulator problem with matrix Ricati equation .
Stochastic process characterisation . Stochastic optimal linear estimation & control . Response of linear continuous time system to white noise and optimal state estimator.

Robust Control:

Parametric uncertainty and Kharitnov's method for stability test. Stability function, complementary sensitivity function and return difference. Effect of high frequency plant uncertainty. Stability robustness. Structured and unstructured uncertainty. Additive and multiplicative perturbation models. Small gain Theorem. Stability robustness measures in frequency domain. Robust performance, tracking problems and disturbance rejection control. Integral control. Internal model principle of robust tracking. The error-space approach. Performance robustness and H∞ norm. Principal Gains and H∞ norm.

Reference Books:

1. Stepheni, Shahian, Savant, Hostetler – Design of feedback control systems, Oxford University Press.
2. Franklin. F., Powell, J .D. , Emami –Naeini,A –Feedback Control of Dynamic Systems, Addison-Weslay Publication.
3. Vidyasagar- Nonlinear system analysis, Prentice-Hall.
4. Gibson, J.E.- Non linear system , Mc. Grawhill.
5. Gopal. M, Modern Control System Theory, New Age International.
6. Gopal. M, Digital Control and State Variable Methods, TMH.
7. Zak.H.S , Systems and Control, Oxford University Press.
8. Peter Dorato,- Robust Control.
9. Morari and Zafirious, - Robust Process Control,

Process Instrumentation and Control

CAM 202
Contact: 4L
Credit: 4

Process characteristics:

Various process schemes / unit operations – Batch and Continuous processes – differences and characteristics. Description and characteristics like large time constants, time lag, etc. of a few processes, such as, heat exchangers, furnaces, boilers and condensers, distillation columns, absorbers, reactors. Mineral processing industries – pH and blending processes

Measurement of process parameters:

Radio isotope and ultrasonic methods of instrumentation and its applications in process industries.
Measurement and transmission of process parameters like flow, pressure, level and temperature – invasive and non invasive techniques
Imaging technique of measurement

Process control methods and control action generation:

Different Control techniques and interaction of process parameters – On-off control, Feed forward, Cascade, Ratio, Override controls, Multivariable control, Optimal control, Adaptive control.
Three term controller as the basic controller. Means of generation of control actions using electronic and pneumatic components.
Digital P-I-D controller – scheme and simulation.

Controller tuning:
Tuning of controllers – Zeigler Nichols, Cohen Coon and other methods.

Final Control elements:
Control valves, valve positioners, torque motors, step motors.

Computer control of processes:
Supervisory control, direct digital control (DDC), distributed computer control.

Reference Books:
1. Harriot, Process Control. TMH, New Delhi
2. Patranabis, D. Principles of Process Control. TMH. New Delhi
3. Coughnower and Koppel Process System Analysis and Control. Mc Graw Hill.
4. Smith, L. Digital Computer Process Control. Intext Education Publishers, 1972
5. Franklin Digital Control of Dynamic Systems. 3rd Edition. Pearson, 2003.
6. Johnson, C. Process Control Instrumentation Technology. PHI, New Delhi.

Power Electronics

CAM 203
Contact: 3L+1T
Credit: 4

Review: Principle of operation of IGBT, GTO, Thyristor family, Principle of operation of SCR, Characteristics, Construction, Rating, Turn on and turn off of a SCR, Phase controlled converters, performance analysis continuous and discontinuous mode of operation.
DC-DC converters: step down, step up, switching mode regulators, multi output boost converter, chopper circuit design, state space analysis of regulators
Pulse-Width-Modulated Inverters: performance parameters, advanced modulation techniques, voltage control of three phase inverters, harmonic reduction, current source inverters, variable DC-link inverter, inverter circuit design
Resonant Pulse Inverters: series-resonant inverter frequency response, parallel-resonant inverters, voltage control of resonant inverters, ZCS and ZVS resonant converters, resonant DC-link inverters.
Multilevel Inverters: multilevel concept, Types of multilevel inverters: diode clamped, flying capacitor, cascaded, applications, switching device currents, DC-link capacitor voltage balancing.

Isolated Switching DC Power Supplies: Comparison between linear & switching power supply, Specification of SMPS, Different topologies, Flyback, Forward, Push –Pull, Half and Full Bridge), Control requirements and techniques, Practical SMPS design considerations, Protection
Power Conditioners and Uninterruptible Power Supplies: Power line disturbances, Power Conditioners. UPS & other residential and industrial applications.

Suggested Readings:
1. Power Electronics Circuits, Devices, and Applications, MH Rashid, 3rd edition, Pearson Education.
2. Robbins, Undeland Mohanand, *Power Electronics*, John Willey & Son's.
3. Cyril W Lander, *Power Electronics*, Mchraw-Hill International Editions, 1993.

4. Philip T. Krein, *Power Electronics.* Oxford university press, 1997.
5. B. K. Bose, *Modern Power Electronics & AC Drives*, Prentice-Hall, 1986.
6. Singh, and Khanchandani, *Power Electronics,* India: Tata McGraw-Hill, 198l.

Real Time Systems

CAM 204(a)
Contact: 4L
Credit: 4

Overview of Real Time Systems: Definition, Evolution, Typology, Structure and applications. Temporal modeling and specification of real time systems, State diagram, Finite automata model, Petri-net, State chart and mode chart, Q-model, Formal methods
Sequential and Logic Control: Ladder diagram, PLC programming, Case studies in interlocking and sequence control
Hardware Components and Configuration of Real Time System: Interfacing systems for analog and digital I/O, Programmable logic control system architecture, Computer control system architecture, Flight control systems, Hardware-in-loop simulation systems, Distributed control architecture, Reliability enhancement by redundancy
Real Time Operating Systems: Features, Primary components, Structured design of real time systems, Data flow oriented method of analysis and design, Mode chart oriented methods, Development, Integration and validation of real time systems, Special consideration for safety critical systems

Suggested Readings:
1. Levi and Agarwal, *Real Time System Design*, Mc Graw Hill New York,1990
2. A. Burns and A. Wellings, *Real Time Systems and Programming Languages*, Addison Wesley, Reading Mass, 2nd ed, 1996.
3. Liu, *Real Time Systems*, Pearson.
4. Bennett, *Real Time Computer Control: An Introduction*, Pearson, 2/e.
5. Meyer, *Real Time Data Handling and Process Control*.

Electric Drives

CAM 204 (b)
Contact: 4L
Credit: 4
Review of Conventional Drives: speed –torque relation, Steady state stability, methods of speed control, braking for DC motor – Multi quadrant operation, Speed torque relation of AC motors, Methods of speed control and braking for Induction motor, Synchronous motor . Criteria for selection of motor for drives.

Converter Control of DC Drives: Analysis of series and separately excited DC motor with single phase and three phase converters operating in different modes and configurations.

Chopper Control of DC Drives: Analysis of series and separately excited DC motors fed from different choppers for both time ratio control and current limit control, four quadrant control.

Design of DC Drives: Single quadrant variable speed chopper fed DC drives, Four quadrant variable speed chopper fed DC Drives, Single phase/ three phase converter, Dual converter fed DC Drive, current loop

control, Armature current reversal, Field current control, Different controllers and firing circuits, simulation.

Inverter fed AC Drives: : Analysis of different AC motor with single phase and three phase inverters Operations in different modes and configurations., Problems and strategies.

Cyclo-converter fed AC Drives: Analysis of different AC motor with single phase and three phase cycloconverters Operations in different modes and configurations., Problems and strategies, vector Control and Rotor side Control

AC Voltage controller fed AC Drives: Speed Control and braking, Analysis of different AC motor with single phase and three phase ac voltage controllers. Operations in different modes and configurations. Problems and strategies.

Control and estimation o AC drives: Induction motor: Small signal models, scalar control, FOC control, sensor less control, DTC, adaptive control. Synchronous motor: sin SPM, synchronous reluctance machines, sin IPM machines, trapezoidal SPM, wound fitted SM, sensor-less operation, switched reluctance machines, Dynamics and Modeling of AC Drives.

Text:

1. Bimal.K. Bose, “Power Electronics and Variable frequency drives”, Standard Publishers Distributors, New Delhi, 2000
2. Murphy J.M.D, Turnbull, F.G, “Thyristor control of AC motor, Pergamon press, Oxford, 1988.
3. M. H. Rashid, "Power Electronics - Circuits, Devices and Applications", P.H.I Private Ltd. New Delhi, Second Edition, 1994
4. N. Mohan et.al. "Power Electronics- Converters, Applications and Design", John Wiley & Sons (Asia) Private Ltd., Singapore, 1996.
5. Bimal K Bose, “ Modern Power Electronics and AC Drives” PHI
6. R. Krishnan, “Electric motor drives: modeling, analysis and control, Pearson.

Reference:

1. Dubey G.K. “Power Semiconductor controlled drives”, Prentice Hall inc, A division of Simon and Schester England cliffs, New Jersey 1989.
2. Sheperal, Wand Hully, L.N. “Power Electronic and Motor control” Cambridge University Press Cambridge 1987
3. Dewan,S. Slemon B., Straughen,A. G.R., “Power Semiconductor drives”, John Wiley and Sons, NewYork 1984.
4. Dubey G.K. “Power Semiconductor controlled drives”, Prentice Hall inc, A division of Simon and Schester England cliffs, New Jersey 1989
5. Dewan,S. Slemon B., Straughen,A. G.R., “Power Semiconductor drives”, John Wiley and Sons, NewYork 1984
6. Sen. P.C. “Thyristor DC Drives”, John Wiley and sons, NewYork, 1981.
7. Subramanyam, V. “Electric Drives – Concepts and applications”, Tata McGraw Hill Publishing Co., Ltd., New Delhi 2003.

Digital Control System

CAM 204 (c)
Contact: 4L

Credit: 4

Z-domain Analysis of Discrete-time system:

Structure of computer control system. Digital signals and coding. Data conversion and Quantization. Sampling and Data hold operation. Zero Order Hold (ZOH) and First Order Hold(FOH). Sampling Theorem. Folding and aliasing. Pulse transfer function. Pulse transfer function of ZOH. Z-transfer function of open `loop and closed loop system. Block diagram and signal flow graph. State diagram of discrete data system with ZOH.

Transient and steady state response of discrete time systems. Steady state accuracy and error constants. Dead beat systems. Stability analysis. Mapping between s and z plane. Characteristic equation. Bilinear Transformation and Routh-Hurwitz Criterion, Jury's test. Effect of sampling rate on stability. Frequency response of discrete time systems. Discrete Nyquist stability criterion, Sensitivity analysis. Disturbance rejection.

State-space Analysis of Discrete- time systems.

State-space representation. Similarity transformations. Transformation to phase variable canonical form. Solution of discrete time state equation. State transition matrix`(STM). Computation of STM by z-transformation method. Diagonalization. Discretisation of continuous time state- space equation. Eigenvalues, eigenvector. Controllability and Observability. Integral control by state augmentation.

Digital Controller design:

Cascade compensation in frequency domain. Commonly used performance indices. Controller design in W-plane for desired steady-state accuracy and phase margin using Bode diagram.
Digital PID controller. Integration and differentiation filters. PI,PD, PID controller design in W-plane using Bode plot for realizing specified phase margin.
Pole Assignment Design based on full state feedback. Hardware implementation for the design.
Design of discrete time system with dead beat response.

Reference Book:

1. Gopal,`M – Digital Control Engineering ,New Age International .
2. Kuo, B . C – Digital Control System , Oxford University Press .
3. Ogata , K . – Descrete Time Control System , Prentice- Hall
4. Phillips , C.L , Nagle , H.T – Digital Control System Analysis & Design Prentice- Hall
5. Franklin .G. E . Powell J .D , Workman , M – Digital Control of Dynamic Systems, Addison-Weslay.
6. Nagrath, I.J . Gopal ,M – Control System Engineering , New Age International Publishers

System Identification and Estimation

CAM205 (a)

Contact: 4L
Credit: 4

Stochastic Processes:

Brief review of probability and random variables; Random processes and their properties: mean, correlation, covariance, power spectral density; stationarity and ergodicity; white noise, colored noise and shaping filter.

System Identification Basics:
Introduction to system identification; Different model structures: AR, MA, ARX, ARMA, ARMAX etc.; Least Square (LS) and Recursive Least Square (RLS) identification and their properties.

Intermediate Topics in System Identification:
Best Linear Unbiased Estimator (BLUE); Concept of Maximum Likelihood (ML) and Instrumental Variable (IV); Introduction to nonlinear identification methods: Wiener and Hammerstein models; Introduction to parametric identification.

Stochastic State Estimation:
Brief review of state observer; Definitions of filtering, prediction and smoothing problems; Kalman Filter (KF) and its applications; Kalman-Bucy filter; Linearised and Extended Kalman Filter (EKF); Joint state and parameter estimation using Extended Kalman Filter.

Suggested Readings:

1. M. Gopal, *Modern Control System Theory*, New Delhi: Wiley Eastern, 2nd Ed, 1993.
2. Franklin and Powell, *Digital Control of Dynamic System*, Prentice Hall of India,
3. Ljung, *System Identification: Theory for the User*,
4. Brown and Hwang, *Introduction to Random Signals and Applied Kalman Filtering with MATLAB Excercises and Solution*, John Wiley & Sons Inc., 1997.
5. R. F. Stengel, *Optimal Estimation and Control*, Dover Publication, 1994.
6. Grewal and Andrews, Kalman Filtering:Theory and Practice, John Wiley and Sons, 2001.
7. Nelles, *Nonlinear System Identification*,
8. Landau and Zito, *Digital Control System*, Springer, 2006

Power System Operation and Control

CAM 205(b)
Contact: 4L
Credit: 4

Economic Operation of Energy Generating Systems: Introduction, Input-output characteristics of thermal and hydel power plants, Incremental fuel cost (IFC) curve, Constraints in economic operation of power system, Analytical approach to determine the economic dispatch problem (without losses and with losses), Loss co-efficients, Transmission loss formula, Derivation of real and reactive power governed loss formula. Optimal power flow using N-R method, Gradient method and linear programming method
Power System Load Flow: Sparse matrix techniques. AC/DC power flow studies, Optimal power flow analysis

Unit Commitment: Introduction to dynamic programming, Unit commitment using dynamic programming method
Load Frequency Control: Automatic load frequency control (ALFC), Turbine speed governing system, Steady-state performance of the speed governing system, Responses of primary ALFC loop (steady-state and transient), Extension of ALFC loop to multi-area systems (two area only), Tie line power flow model
Hydro-thermal Scheduling: Optimum scheduling of hydro-thermal system, Aspects of hydro scheduling, Cost of water, Long-term energy scheduling in a hydro-thermal system, Short-term hydrothermal
scheduling, Hydro-thermal scheduling with network losses considered, A modern approach to hydro-thermal scheduling
State Estimation: Static as well as dynamic
Deregulation: What is deregulation? Background to deregulation and current situation, Benefits of a competitive electricity market,

Suggested Readings:
1. Abhijit Chakrabarti, and Sunita Halder, *Power System Analysis: Operation and Control*, India: Prentice Hall.
2. D. P Kothari, and I. J. Nagrath, *Modern Power System Analysis*, India: Tata McGraw Hill, 3rd edition.
3. O. I. Elegard, *Electric Energy Systems Theory, An Introduction*, India: Tata McGraw Hill, 2nd edition.

Remote Sensing and Control

CAM 205 (c)
Contact: 4L
Credit: 4

Electromagnetic radiation:

Classification and nature, spectral, spatial and temporal characteristics of objects.

Atmospheric interaction sensors:

Photographic, thermal, multi-spectral, passive microwave and active microwave sensors.

Ground data acquisition:

Photo-interpretation, image processing techniques, remote sensing applications.

Techniques of remote control:

Remote control in industry including oil pipelines, rocket motion and satellite movements.

Reference Books

1. Gupta - Remote Sensing Ecology, 2nd edition, Springer, 2005
2. Jensen - Remote Sensing of the Environment, Pearson, 2003
3. Barett, E.C. and Curtis, L.F. Introduction To Environmental Remote Sensing, 3/e, Chapman Hall, New York 1992.

4. Lo, C.P. Applied Remote Sensing, Wiley, New York 1986.

Topic in management

EMM-301

Contact: 4L

Credit: 4

(Syllabus Centrally)

Robotics

CAM 301 (a)
Contact: 4L
Credit: 4

Basic concepts : Definition and origin of robotics – different types of robots – various generations of robots – degrees of freedom – Asimov's laws of robotics – Dynamic stabilization of robots.
Power sources and sensors : Hydraulic, pneumatic and electric drives – Determination of HP of motor and gearing ratio – variable speed arrangements – path determination – machine vision – ranging – laser-acoustic – magnetic – fibre optic and tactile sensors.
Manipulators, Actuators and Grippers : Construction of manipulators – manipulator dynamic and force control – electronic and pneumatic manipulator control circuits – and effectors – various types of grippers – design considerations.

Ref. Book:

1. Mair, G.M. –Industrial Robotics, Prentice Hall, NY, 1988.
2. Khafter, R.D., Chimelewski, T.A. and Negin, M. – Robot Engineering – An Integrated Approach, PHI, New Delhi, 1994.
3. Braddley, M. et. Al. (Eds) – Robot Motion: Planning and Control, MIT Press, Cambridge, Mass, 1982.
4. Lee, C.S.G. – Robot Arm Kinematics, Dynamics and Control, Computer, IEEE, Vol. 15, No. 12.
5. Paul, R.P. – Robot Manipulators: Mathematics, Programming and Control, MIT Press, Cambridge, Mass, 1981.
6. Mittal and Nagrath,- Robotics and Control, Tata Mc. Graw Hill,.
7. Sponge, M., and Vidyasagar M- Robot Dynamics and Control, John Wiley New York 1989.

8. Craig J.J.- Introduction to Robotics; Mechanisms and Control, 2/e, Addison Wesley, Reading, Mass 1989.

Biomedical Instrumentation

CAM 301 (b)
Contact: 4L
Credit: 4

Introduction to Physiology:
Cardiac, nervous, muscular and respiratory systems, Nerst equation, Sodium-Potassium pump theory, Action potential, Bio-signals and sensors, Electrical activities of heart and brain and different measurement techniques, ECG models, ECG measurement and instrumentation techniques, VCG measurement, ICCU and patient monitoring
Medical Equipment:
Plethysmography, Diathermy, Defibrillator, Pace maker, Blood pressure monitor, Blood flow monitor, Endoscope, Audiometry, Pulmonary function analyzer
Instrumentation in Clinical Laboratory:
Measurement of pH, ESR, oxygen, Hb in blood, X-ray and radio isotope equipment
Medical Imaging:
Ultra sonograph, CT scan, Magnetic resonance imaging (MRI), Positron emission tomography (PET)

Suggested Readings:
1. Cromwell, Weibell, and Pfeiffer, *Biomedical Engineering and Instrumentation & Measurement*, India: Prentice Hall.
2. Carr, and Brown, *Introduction to Biomedical Equipment Technology*, Asia: Pearson Education.
3. Wills J. Tompkins, *Biomedical Digital Signal Processing*, India: Prentice Hall.
4. Geddes, and Baker, *Principles of Applied Biomedical Instrumentation*, Wiley.
5. R. S. Khandpur, *Handbook of Bio-medical Instrumentation*, India: Tata McGraw Hill.
6. A. Cohen, *Biomedical Signal Processing: Vol.-I, Time Frequency Analysis*, CRC Press.
7. J. Webster, *Medical Instrumentation-Application & Design*,
8. Joseph Bronzino, *Biomedical Engineering and Instrumentation*, Boston: PWS Engineering.
9. P. W. Macfarlane, *Computer Technique in Medicine*, Butterworth.
10. R. Weitkumat, *Digital Biosignal Processing*, Elsevier.

Intelligent Control

CAM 301 (c)
Contact: 4L
Credit: 4

Module 1 - Adaptive Control: Introduction, close loop and open loop adaptive control. Self-tuning controller, parameter estimation using least square and recursive least square techniques; Gain Scheduling; Model Reference Adaptive Control; Self Tuning Regulators, Adaptive Smith predictor control: Auto-

tuning and self-tuning Smith predictor. (14L)

Module 2 – Artificial Neural Network (ANN) Based Control: Introduction to ANN, different activation functions, different architectures, different learning methods; Back Propagation and Radial Basis Function networks: Representation and identification, modeling the plant, control structures – supervised control, Model reference control, Internal model control, Predictive control, Indirect and direct adaptive controller design using neural network. (14L)

Module 3 – Fuzzy Logic Based Control: Fuzzy Controllers: Preliminaries – Mamdani and Sugeno inference methods, Fuzzy sets in commercial products – basic construction of fuzzy controller – fuzzy PI, PD and PID control; analysis of static properties of fuzzy controller – Analysis of dynamic properties of fuzzy controller – simulation studies – case studies - Stability issues in fuzzy control. (10 L)

Module 4 – Hybrid Control: Introduction to Genetic Algorithm(GA); Neuro-Fuzzy and Fuzzy-GA based hybrid system design. (4L)

REFERENCES:

1. Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, Prentice Hall of India, New Delhi 1994.
2. Bose and Liang, Artificial Neural Networks, Tata Mcgraw Hill, 1996.
3. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, New Delhi, 1992.
4. Astrom .K, Adaptive Control, Second Edition, Pearson Education Asia Pvt. Ltd, 2002.
5. Chang C. Hong, Tong H. Lee and Weng K. Ho, Adaptive Control, ISA press, Research Triangle Park, 1993.