APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Cluster No. 10 for PG Programs

(Engineering Colleges in Kannur, Wayanad & Kasaragod Districts)

Curriculum, Scheme of Examinations and Syllabi for M. Tech. Degree Program with effect from Academic Year 2015 - 2016

Department of Electronics and Instrumentation Engg.

M. Tech.
in
Control and Instrumentation

[Total Credits : 66]

CURRICULUM STRUCTURE FOR M. TECH PROGRAMME IN CONTROL & INSTRUMENTATION UNDER KTU

FIRST SEMESTER

Exam Slot	Code	Subject	Hours/Week			Internal Marks	End Semester Examination		Credit
			L	T	P		Hrs	Marks	
A	10EI6101	Applied Mathematics in Control Theory	3	1	-	40	3	60	4
B	10EI6103	Industrial Instrumentation	3	-	-	40	3	60	3
C	10EI6105	Process Dynamics and Control	3	-	-	40	3	60	3
D	10EI6107	Modern Control Systems	3	-	-	40	3	60	3
E	10EI61XX	Elective-I	3	-	-	40	3	60	3
S	10GN6001	Research Methodology	0	2	-	100	-	0	2
T	10EI6109	Seminar-I	-	-	2	100	-	0	2
U	10EI6111	Industrial Instrumentation Lab	-	-	2	100	-	0	1
	TOTAL		**15**	**2**	**2**	**500**		**300**	**21**

ELECTIVE-I

10EI6113 Multisensor Data Fusion
10EI6115 Chemical Process Systems
10EI6117 Communication Protocols for Instrumentation
10EC6103 Random Processes and Applications
10EE6113 Special Machines

SECOND SEMESTER

Exam Slot	Code	Subject	Hours/Week			Internal Marks	End Semester Examination		Credit
			L	T	P		Hrs	Marks	
A	10EI6102	Biomedical Instrumentation	3	-	-	40	3	60	3
B	10EI6104	System Identification and Adaptive Control	3	-	-	40	3	60	3
C	10EI6106	SCADA Systems and Applications	3	1	-	40	3	60	4
D	10EI61XX	Elective-II	3	-	-	40	3	60	3
E	10EI61XX	Elective-III	3	-	-	40	3	60	3
T	10EI6108	Mini Project	-	-	4	100	-	0	2
U	10EI6112	Process Control Lab	-	-	2	100	-	0	1
	TOTAL		**15**	**2**	**6**	**400**		**300**	**19**

Electives II

10EC6404 Adaptive signal processing
10EC6102 Digital image processing
10EE6104 Control techniques in power electronics
10EC6116 Fiber optic communication
10EI6114 Principles of robotics

Electives III

10EC6304 Embedded system design
10EI6116 Bioprocess instrumentation and control
10EI6118 Real time operating systems

10EC6204 Digital system design using VHDL
10EI6122Advanced topics in non linear control

THIRD SEMESTER

Exam Slot	Code	Subject	Hours/Week			Internal Marks	End Semester Examination		Credit
			L	T	P		Hrs	Marks	
A	10EI71XX	Elective-IV	3	-	-	40	3	60	3
B	10EI71XX	Elective-V	3	-	-	40	3	60	3
T	10EI7101	Seminar-II	-	-	2	100	-	0	2
U	10EI7103	Project - Phase I	-	-	12	50	-	0	6
	TOTAL		**6**	**-**	**14**	**230**		**120**	**14**

Electives IV

10EC7105 Audio processing
10EC7207 Micro electro mechanical systems
10EI7105 Optimal control theory
10EI7111Microcontroller based system design

Electives V

10EI7107 Digital control systems design
10EC7507Soft computing
10EC7113 Pattern recognition
10EI7113 Piping & instrumentation

FOURTH SEMESTER

Exam Slot	Code	Subject	Hours/Week			Internal Marks	End Semester Examination		Credit
			L	T	P		Hrs	Marks	
U	10EI7104	Project - Phase II	-	-	22	70	1	30	12
	TOTAL		**-**	**-**	**22**	**70**		**30**	**12**

L-Lecture T-Tutorial P-Practical
ICA-Internal Continuous Assessment
ESE- End Semester Examination

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6101	APPLIED MATHEMATICS IN CONTROL THEORY	3-1-0- 4	2015

Course Prerequisites
Basic knowledge in Matrix Theory at UG level and basic Statistics

Course Objectives
To have an advanced level knowledge on linear algebra, Statistics and its applications..

Syllabus
Vector spaces, Linear transformations, Eigen values and vectors, Simplex and two phase methods, transportation and assignment problems, Random variables, Discrete and continuous distributions, introduction to queuing theory, Curve fitting, correlations and regressions .

Expected Outcomes
At the end of the course students will be able:

- to apply the general principles of linear algebra,
- to analyse the systems with eigen values and vectors
- to solve the various linear programming techniques including simplex and two phase methods
- to acquire knowledge of various probability and statistical distributions
- to analyse queing models
- to use curve fitting techniques for modeling analysis of data sets

References
1. Hoffman Kenneth and Kunze Ray, *Linear Algebra,* Prentice Hall of India.
2 Taha H.A., Operations Research: An Introduction, Seventh edition, Pearson Education Edition, Asia, New Delhi (2002).
3. R.E. Walpole, R.H.Myers, S.L. Myers and K.Ye, Probability and Statistics for Engineers & Scientists, Asia, 8th Edition (2007).
4. Donald M.Gross and Carl M. Harris, Fundamentals of Queuing theory, 2nd edition, John Wiley and Sons, New York (1985).
5. Grewal B.S., Numerical Methods in Engineering and Science, 7th edition, Khanna Publishers, 2000.

Module	Content	Hours	Semester Exam Marks (%)
I	**Linear Algebra**: Vector spaces- subspaces- Linear dependence- Basis and dimension	6	15
II	**Linear transformations**- Kernals and Images- Matrix representation of linear transformation- Change of basis- Eigen values and vectors-Cayley Hamilton theorem	7	15
	First Internal Examination		
III	**Linear Programming**: Formulation- Graphical Solution – Simplex method – Two Phase Method – Transportation and assignment problems	10	15
IV	**One dimensional Random Variables**: Random variables- Probability function – moments – moment generating function and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal Distributions – Function of a random variable	10	15
	Second Internal Examination		
V	**Queuing Models**: Poisson process – Markovian queues – Single and multi server r models – Little's formula – Machine Interference model – Steady state analysis – Self service queue	9	20
VI	**Curve fitting**: Method of least squares – Normal equations – Fitting of straight line – Fitting of second degree curve – Correlations and regressions – Curvilinear regression – Multiple regression & multiple correlation	10	20

Cluster Level End Semester Examination

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6103	**INDUSTRIAL INSTRUMENTATION**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of Transducers, electronic circuits and digital instrumentation at UG/PG Level.

Course Objectives

To enable students acquire knowledge about the various techniques used for the measurement of industrial parameters, monitoring and their safety considerations.

Syllabus

Review of Industrial Instrumentation- Industrial signal conditioning systems- Calibration-testing- System response- Introduction to EMC- safety and Protection methods- Concept of virtual instrumentation

Expected Outcomes

At the end of the course students will be able:

- To select and describe the operation of instruments and transducers for various physical variables including pressure, temperature, fluid flow and others.
- To design various signal conditioning systems for transducers.
- To enable them to follow industrial procedures while calibration.
- To analyze dynamic responses of various systems.
- To understand various industrial safety procedures.
- To get an insight on data acquisition, processing and monitoring system.

References

1. E. O. Doebelin, Measurement Systems - Application and Design, Fifth Edition,Tata McGraw-Hill International Edition, New York, 2005.
2. Dale E. Seborg, Thomas F. Edgar, Duncan A. Melli Champ, Process Dynamics and Control, Second Edition, Wiley-India, 2011.
3. Gary Johnson, LabVIEW Graphical Programming, Second edition, McGraw Hill, New York, 1997.
4. Curtis D. Johnson, Process Control Instrumentation Technology, Eighth Edition, Prentice Hall, 2011.
5. Noltingk B.E., Instrumentation Reference Book, 2nd Edition, Butterworth Heinemann, 1995.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Review of Industrial Instrumentation:-** Measurement of Force, Torque, Velocity, Acceleration, Pressure, Temperature, Flow, Level, Viscosity, Humidity & Moisture (Qualitative Treatment Only).	4	15
	Piezo-electric and ultrasonic transducers - application in process and biomedical Instrumentation.	3	
II	**Industrial signal conditioning systems**- Design of signal conditioning circuits for various Resistive, Capacitive, Inductive transducers and piezoelectric transducer.	4	15
	Amplifiers – Filters – A/D converters for industrial measurements systems, Smart and intelligent transmitters - Design of transmitters.	3	
First Internal Examination			

III	**Calibration** and response of industrial instrumentation - standard testing methods and procedures.	7	15
IV	**System response:-** Generalized performance characteristics – static response characterization – dynamic response characterization	5	15
Second Internal Examination			
V	**Introduction to EMC**, interference coupling mechanism, basics of circuit layout and grounding, concept of interfaces, filtering and shielding.	3	20
	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.	4	
VI	**Concept of virtual instrumentation** – PC based data acquisition, Block diagram and architecture of a virtual instrument Data flow techniques - Graphical programming in data flow - Comparison with conventional programming Development of virtual Instrument using Graphical User Interface (GUI).	7	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EI6105	**PROCESS DYNAMICS AND CONTROL**	**3-0-0- 3**	**2015**

Course Prerequisites

NIL

Course Objectives

The course is designed to provide students a strong background in the concept of chemical process modelling and control. It discusses the various components and different types of process control arrangements.

Syllabus

Review of Process and Control Systems, Modelling and Dynamic aspects of first order process, Design aspects of Process Control System, Modes of controllers: P,PI,PID, Controller tuning, Control System components, Other control schemes, Selection of controllers, Programmable Logic Controllers

Expected Outcomes

At the end of the course students will be able:

- to model and analyse various dynamic process control systems
- to design feedback controllers including PID controller to achieve required performance
- to get an overview of various control system components
- to select proper control valves and actuators
- to acquire knowledge of various controllers like feedforward controllers, PLC etc
- to study the affect of dead time in the system performance

References

1. George Stephanopoulos, Chemical Process Control, Prentice Hall of India. 2005
2. Caughanour and Koppel, Process systems analysis and control, Tata McGraw Hill. 3rd edition 2008

3. Curtis D. Johnson, Process Control Instrumentation Technology, Eighth Edition, Prentice Hall, 2011
4. Dale E. Seborg, Process Dynamics and Control, John Wiley. 2009

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Review of Process and Control Systems:** Introduction to control systems, Need for process control, Process control principles, Process control block diagram, Identification of elements, Servomechanism, Self-regulation	3	15
	Modelling and Dynamic aspects of first order process – Process modelling– First order process- Examples of modeling of first order systems – Example of modeling of stirred tank heater- Linearization of non-linear model- Dynamics of liquid process, gas process, flow process, thermal process, mixing process.	4	
II	**Design aspects of Process Control System:** Feedback control, Classification of variables, Design elements of a control system, control aspects of a process. Degrees of freedom and process controllers, Degrees of freedom and design of controllers- case study with a process.	4	15
	Modes of controllers: P,PI,PID: . Modes of operation of P, PI and PID controllers. Effect of variation of controller variables. Controller Tuning – Ziegler Nichols and Cohen Coon Methods.	3	
First Internal Examination			
III	**Control system components :** : I/P and P/I converters, Valve positioner -valve body - globe, butterfly, diaphragm, ball valves	7	15
IV	**Valves and Actuators :** control valve sizing - Cavitation, flashing in control valves – Control valve characteristics - Actuators – Pneumatic, Hydraulic, Electrical/ Electronic.	7	15
Second Internal Examination			
V	**Other control schemes:** Feed forward controllers, Ratio Control, Cascade Control, Override control, Auctioneering control, Adaptive Control	3	20
	`Selection of controllers: Stability considerations. Simple performance criteria, Time integral performance criteria: ISE, IAE, ITAE, Problems in selection and design of feedforward controller.	4	
VI	Processes with large dead time. Dead time compensation. Control of systems with inverse response.	4	20
	Programmable Logic Controllers – ladder diagram, Examples of industrial control systems using PLC.	3	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6107	**MODERN CONTROL SYSTEMS**	**3-0-0- 3**	**2015**

Course Prerequisites
Knowledge of Laplace transform, Z-transform, matrix algebra and acquaintance with basic concepts of

control theory.

Course Objectives

The course is designed to enable students to apply tools and concepts of modern control theory to solve problems involving linear and non-linear as well as SISO and MIMO systems.

Syllabus

Introduction to control systems, State space analysis, Multivariable Control Systems Analysis, Multivariable Control Systems Design, Non-linear system analysis, Describing function analysis.

Expected Outcomes

At the end of the course students will be able to

1. Formulate transfer function and state models of physical systems.
2. Analyze the controllability and observability of a given system.
3. Analyse the effect of state feedback
4. Design observers for various physical systems
5. Understand the characteristics of a given non-linear system.
6. Predict the response of a non-linear system using describing function.

References

1. Brogan W. L, Modern Control theory, Prentice Hall International, New Jersey, 1991.
2. Katsuhiko Ogata, Modern Control Engineering, Prentice Hall, 2010
3. Jean-Jacques E. Slotine, Weiping Li, Applied nonlinear control, Prentice Hall Inc., New Jersey, 1991.
4. T. Kailath, Linear Systems, Prentice-Hall, Englewood Cliff's, NJ, 1980
5. Skelton R. E, Dynamic System Control and Linear System Analysis and Synthesis, John Wiley and Sons Inc., New Delhi, 1993.
6. Vidyasagar .M, Nonlinear system analysis, Second Edition, Prentice Hall Inc., New Jersey, 1993
7. Nonlinear Control, Global Edition, Hassan K. Khalil, Global Edition, 1/E, ISBN-13: 9781292060507, Pearson, (2014).

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to control systems** – Introduction to control systems, properties of signals and systems. Convolution integral, Ordinary differential equation, Transfer function, Pole zero concepts, effect of pole location on performance specification.	4	15
	State space analysis - System models in state space, canonical models, MIMO systems, solution of state equation, stability of systems in state space. State space analysis of discrete-time systems.	3	
II	**Multivariable Control Systems Analysis:** Concept of Controllability, Observability and Reachability, Controllability and Observability tests: Kalman's test matrix, Gilbert's test, Controllability and Observability canonical forms.	7	15
	First Internal Examination		
III	**Multivariable Control Systems Design:** Linear state variable feedback: The effect of state feedback on controllability and observability, Condition for arbitrary pole placement, Ackermann's formula for pole placement.	7	15

IV	**State observers:** Full order state observers and minimum order observers. Study of some physical plant like inverted pendulum for analysis and design.	7	15
Second Internal Examination			
V	**Non-linear system analysis:** Non-linear system behaviour, different methods of linearization, Lyapnov stability criterion. Phase plane analysis, singular points, constructing phase portraits, existence of limit cycle.	7	20
VI	**Describing function analysis:** Fundamentals, assumptions, definitions. Describing functions of common non-linearities. Describing function analysis of non-linear systems. Stability of limit cycles, reliability of describing function analysis.	7	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EI6113	**MULTI SENSOR DATA FUSION**	**3-0-0- 3**	**2015**

Course Prerequisites

Students are expected to have prior experience with state estimation methods.

Course Objectives

The focus of the course is on multiple-sensor estimation methods and to provide practical knowledge to employ and develop multi-sensor data fusion systems.

Syllabus

Multisensor Data Fusion Introduction, inference hierarchy, Benefits of data fusion, Mathematical tools, Algorithms For Data Fusion, Data association, Estimation, Advanced Filtering, Optimal sensor fusion, High Performance Data Structures, Designing optimal sensor systems.

Expected Outcomes

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

1. Describe the data fusion model and applications.
2. Understand the benefits of data fusion.
3. Provide both the theoretical and practical skills necessary to design and implement data fusion algorithms.
4. Understand the concepts of advanced filtering methods.
5. Discover the perception behind decentralized estimation.
6. Depict the design of optimal sensor systems and different data structure representations.

References

1. David L. Hall, Mathematical techniques in Multisensor data fusion, Artech House, Boston.
2. R.R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey,
3. Arthur Gelb, Applied Optimal Estimation, The M.I.T. Press
4. James V. Candy, Signal Processing: The Model Based Approach, McGraw –Hill Book Company, 1987

Module	Content	Hours	Semester Exam Marks (%)
I	Multisensor Data Fusion Introduction**:** sensors and sensor data, Use of multiple sensors, Fusion applications	4	15
	The inference hierarchy: output data. Data fusion model. Architectural concepts and issues.	3	
II	Benefits of data fusion, Mathematical tools used: Algorithms, co-ordinate transformations.	3	15
	Rigid body motion. Dependability and Markov chains, Meta – heuristics.	4	
First Internal Examination			
III	Algorithms For Data Fusion: Taxonomy of algorithms for multisensor data fusion.	3	15
	Data association. Identity declaration. Decision level identify fusion. Knowledge based approaches.	4	
IV	Estimation**:** Kalman filtering, practical aspects of Kalman filtering, extended Kalmal filters.	4	15
	Advanced Filtering: Data information filter, extended information filter.	3	
Second Internal Examination			
V	Decentralized and scalable decentralized estimation. Sensor fusion and approximate agreement.	3	20
	Optimal sensor fusion using range trees recursively. Distributed dynamic sensor fusion.	4	
VI	High Performance Data Structures: Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures.	4	20
	Designing optimal sensor systems within dependability bounds. Implementing data fusion system.	3	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6115	**CHEMICAL PROCESS SYSTEMS**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of thermodynamics, chemical reactions at UG/PG Level.

Course Objectives

The course is designed to provide students a strong background in the concept of Chemical processes , equipment and Energy conservation principles in chemical industries

Syllabus

Analysis of chemical processes, General Principles ofProcess Analysis,OverallBalance Equations, Energy Balancing and Heat transfer, Analysis of process Equipment, Process Equipment Classification, Principles and analysis on Energy Conservation and consumption

Expected Outcomes

The students are expected to apply the general principles of chemical process design and reaction engineering.

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References

1. W.L. McCabe, J.C. Smith and P. Harriott, "Unit Operations of Chemical Engineering", sixth Edition, McGraw Hill, 2001.

2. Walter L.Badger and Julivst. Banchero "Introduction to Chemical Engineering", Tata McGraw Hill publishing company, 1997

3.L.B. Anderson and L.A. Wenzel, "Introduction to Chemical Engineering", McGraw Hill, 1961.

4.P.Harriot, "Process Control", McGraw Hill, 1984.

5.D.A. Reay, "Industrial Energy Conservation", McGraw-Hill, New York, 1979.

Module	Content	Hours	Semester Exam Marks (%)
I	Analysis of chemical processes**:**Typical products and their and uses, Systematic analysis of chemical processes. Flow sheets and symbols for various operations	4	15
	Process Analysis: Variation in process conditions, raw materials and fuels – effect on end products and economy.	4	
II	Balance Equations: Overall Balances, Component balances in engineering equipments.	4	15
	Component balances in combustion reactions, Stoichiometric balances in manufacturing processes	4	
First Internal Examination			
III	Energy Balancing and Heat transfer :-Forms of energy, Total balance, Heat balance, Heat effects and combustion reactions,Energy balances in manufacturing processes, optimum utilization of energy, Heat transferoperations in chemical reactors.	6	15
IV	Chemical Equipments- Fundamental concepts in heat exchangers,Evaporators and distillation column, Design and classification of heat exchangers,Evaporators and distillation column.	6	15
Second Internal Examination			
V	Process Equipment Classification: Fundamental principles and classification of heat exchangers, Evaporators, Distillation columns	4	20

	Equipment for Agitation and mixing of fluids dimensional analysis to estimate power consumption for agitation.	4	
VI	Energy Conservation:Energy Conservation in process systems and industries, Optimization principles and pinch analysis to calculate energy consumption.	6	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EI6117	**COMMUNICATION PROTOCOLS FOR INSTRUMENTATION**	**3-0-0- 3**	**2015**

Course Prerequisites
Nil

Course Objectives
1)To study about Networks in process automation
2) To understand various communication protocols
3)To introduce the communication buses namely field bus and profibus.

Syllabus
Networks in process automation, OSI reference model, Communication Protocols, Proprietary and open networks, HART, , Ethernet, Fieldbus, wireless Protocols

Expected Outcomes
At the end of the course, students will be able::
- To become familiar with various Network technologies
- To acquire knowledge on communication protocols
- To identify the basic building blocks of open networks etc
- To compare between Ethernet, modbus type networks
- To design and install field bus and profibus
- To design and install HART.

References:
1. Noltingk B.E., "*Instrumentation Reference Book*", 2nd Edition, Butterworth Heinemann, 1995.
2. B.G. Liptak, Process software and digital networks, 3rd Edition, CRC press, Florida.
3. Romilly Bowden ,'HART Communications Protocol', (Fisher-Rosemount).

Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	OSI reference model, Industry Network, Recent networks	6	15
II	Introduction to Communication Protocols: Communication basics, Network Classification, Device Networks, Control Networks, Enterprise Networking, Network selection.	8	15

First Internal Examination			
III	Proprietary and open networks: Network Architectures, Building blocks, Industry open protocols (RS-232C, RS- 422, RS-485)	7	15
IV	Ethernet, Modbus, Modbus Plus, Data Highway Plus, Advantages and Limitations.	7	15
Second Internal Examination			
V	Fieldbus: Fieldbus Trends, Hardware selection, Fieldbus design, Installation, Documentation,	4	20
	Foundation Fieldbus & Profibus-Introduction, Design, Calibration, Commissioning, Advantages and limitations.	3	
VI	HART- Introduction, Design, Installation, calibration, commissioning, Applications	3	20
	Introduction to wireless Protocols- WPAN, Wi-Fi, Bluetooth, ZigBee, Z-wave.	4	
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L - T - P - Credits**	**Year of Introduction**
10EC6103	**RANDOM PROCESSES AND APPLICATIONS**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in Probability Theory at UG level
(2) Basic knowledge in Set Theory at UG level

Course Objectives

(1) To impose in-depth knowledge in probability theory.
(2) To throw light into the applications of probability and random processes.

Syllabus

Review of Set Theory, Random experiment, Sample space, Cumulative Distribution Function, Probability Density Function, conditional distribution, Expectation, moments, correlation and covariance, Random Vector, Convergence - Markov and Chebyshev inequalities, convergence in probability, convergence in mean square, Weak law of large numbers, strong law of large numbers, Central Limit Theorem for sequences of independent random variables, Random process, IID process, Poisson counting process, Markov process, Wiener process. Stationarity, power spectral density, Discrete time Markov chains, conditional independence, DTMC, Recurrence analysis, Chapman-Kolmogov theorem, Communicating classes, Continuous time Markov chains, Poisson process, simple Markovian queues.

Expected Outcomes

The students are expected to :
(1) Have an advanced level knowledge in probability theory;
(2) Know how the theory of probability and random processes could be applied in specific domains

References

1. A. Papoulis and S. UnnikrishnaPillai. *Probability, Random Variables and Stochastic Processes*, TMH
2. B. Hajek, *An Exploration of Random Processes for Engineers*, 2005.
3. D.P. Bertsekas and J. N. Tsitsiklis, *Introduction to Probability*, 2000.

4. Gray, R. M. and Davisson L. D., *An Introduction to Statistical Signal Processing.* Cambridge University Press, 2004.
5. Stark Henry, *Probability and Random Processes With Application to Signal Processing*, 3/e, Pearson Education India.
6. Steven Kay, *Intuitive probability and random processes using MATLAB*, Springer, 2006.
7. Dr. Kishor S. Trivedi. *Probability and Statistics with Reliability, Queuing, and Computer Science Applications*, John Wiley and Sons, New York, 2001.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Review of Set Theory - Set operations, functions, countable and uncountable sets, Random experiment, Sample space, Sigma algebra, Event space, Measure, Probability measure, Borel sigma field	4	15
	Cumulative Distribution Function (CDF), Probability Density Function (PDF), PMF, Joint CDF, Joint PDF, conditional distribution.	4	
II	Expectation - Fundamental Theorem of expectation, moments, characteristic function, correlation and covariance	4	15
	Random Vector - Definition, Joint statistics, Covariance and correlation matrix, Gaussian random vectors.	4	
First Internal Examination			
III	Convergence - Markov and Chebyshev inequalities, Convergence of sequences of random variables- almost sure convergence, convergence in probability, convergence in mean square, Weak law of large numbers, Random sums, Borel Cantelli lemma, strong law of large numbers, Central Limit Theorem for sequences of independent random variables.	8	15
IV	Random process - Definition of Random process, IID process, Poisson counting process, Markov process, birth-death process, Wiener process. Stationarity, Correlation functions of random processes in linear systems, power spectral density.	8	15
Second Internal Examination			
V	Discrete time Markov chains - conditional independence, DTMC, Recurrence analysis, Foster's Theorem, Chapman-Kolmogov theorem, Stopping time.	6	20
VI	classification of states: absorbing, recurrent, transient. Communicating classes, Continuous time Markov chains, Poisson process, simple Markovian queues.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6113	**SPECIAL MACHINES**	**2-1-0:3**	**2015**

Course Prerequisites

Basic knowledge of Electrical Machines at UG Level.

Course Objectives

To impart knowledge about special machines

Syllabus

Stepper motor, Servomotor, Synchronous Reluctance motor, Switched reluctance motor, Permanent magnet BLDC motor & PMAC Motor, Linear Induction motor**.**

Expected Outcomes

The students are expected to apply the general principles of special machines for various industrial applications and house hold applications.

Text books

1. T.J.E. Miller, Brushless Permanent-Magnet and Reluctance Motor Drives, Clarendon Press.
2. R.Krishnan, Switched Reluctance Motor Drives-Modelling, Simulation, Analysis, Design and application, CRC press New York,2001
3. T. Kenjo, 'Stepping Motors and Their Microprocessor Controls', Clarendon Press London, 1984.T.J.E. Miller, Switched Reluctance Motors And Their Control , Magna physics Publishing, Oxford.
4. T.J.E. Miller, Electronic Control of Switched Reluctance Machines, Newnes Power Engineering Series.
5. Vincent Del Toro, Electric Machines and Power Systems, Prentice Hall
6. M D Desai, Control system components, PHI
7. K Venkataratnam, Special Electrical Machines, Universities press(India) Pvt. Ltd. Hyderabad
8. R Krishnan, Electric Motor Drives, Modeling, Analysis, and control, PHI
9. Nasar S.A., Boldea I., Linear Motion Electric Machine, John Wiley & Sons.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Stepper motor:** Constructional features - Principle of operation- permanent magnet stepper motor - variable reluctance motor - hybrid motor-single and multi stack configurations - Torque equations - modes of excitations - drive circuits-microprocessor control of stepping motors - closed loop control – applications.	8	15
II	**Servomotor:** DC servomotors- construction - principle of operation- transfer function - armature control and field control - AC servomotor- construction - theory of operation - shaded pole ac servomotors – applications.	6	15
	First Internal Examination		
III	**Synchronous Reluctance motor**: Constructional features - Types - Principle of operation - Axial and radial flux motors - operating principles - variable reluctance motor - hybrid motor - voltage and torque equations – characteristics – applications.	8	15
IV	**Switched reluctance motor**: Constructional features - principle of operation - torque production - steady state performance prediction- Analytical method - Power converters and their controllers - Methods of rotor position sensing - Closed loop control of SRM – Characteristics – applications.	6	15
	Second Internal Examination		
V	**Permanent magnet motor:** Permanent magnet brushless DC motors - Permanent magnetic materials - Magnetic characteristics - Principle of operation -Types-Magnetic circuit analysis - Torque equations - Power controllers - Motor characteristics and control, Permanent magnet synchronous motors-Principle of operation--Torque equations-characteristics and control.	8	20
VI	**Linear Induction motor** Linear induction motor- Double sided linear induction motor from rotary type Induction motor – Scheme of LIM	6	20

	drive for electric traction – development of single sided LIM – Equivalent circuit- applications.		
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10GN6001	**RESEARCH METHODOLOGY**	**0 - 2 - 0 - 2**	**2015**

Course Prerequisites

(1) Basic skill of analyzing data earned through the project work at UG level;
(2) Basic knowledge in technical writing and communication skills earned through seminar at UG level.

Course Objectives

(1) To attain a perspective of the methodology of doing research;
(2) To develop skills related to professional communication and technical report writing.
As a tutorial type course, this course is expected to be more learner centric and active involvement from the learners are expected which encourages self-study and group discussions. The faculty mainly performs a facilitator's role

Syllabus

Overview of research methodology - research process - scientific methods -research problem and design - research design process - formulation of research task, literature review and web as a source - problem solving approaches - experimental research - ex post facto research. Thesis writing - reporting and presentation - interpretation and report writing - principles of thesis writing- format of reporting, oral presentation - seminars and conferences, Research proposals - research paper writing - publications and ethics - considerations in publishing, citation, plagiarism and intellectual property rights. Research methods – modeling and simulation - mathematical modeling – graphs - heuristic optimization - simulation modeling - measurement design – validity – reliability – scaling - sample design - data collection methods and data analysis.

Expected Outcomes

The students are expected to :
(1) Be motivated for research through the attainment of a perspective of research methodology;
(2) Analyze and evaluate research works and to formulate a research problem to pursue research;
(3) Develop skills related to professional communication, technical report writing and publishing papers.

References

1. C.R Kothari, *Research Methodology : Methods & Techniques*, New Age International Publishers
2. R. Panneerselvam, *Research Methodology*, Prentice Hall of India, New Delhi, 2012.
3. K. N. Krishnaswamy, Appa Iyer Sivakumar, and M. Mathirajan, *Management Research Methodology, Integration of Principles*, Pearson Education.
4. Deepak Chawla, and MeenaSondhi, *Research Methodology – Concepts & Cases*, Vikas Publishing House.
5. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
6. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
7. Willktnsion K. L, Bhandarkar P. L, *Formulation of Hypothesis*, Himalaya Publication.
8. Douglas C Montgomery, *Design and analysis of experiments*, Wiley International
9. Ranjit Kumar, *Research Methodology : A step by step guide for beginners*, Pearson Education.
10. Donald Cooper, *Business Research Methods*, Tata McGraw Hill, New Delhi.
11. Leedy P D, *Practical Research : Planning and Design*, 4th Edition, N W MacMillan Publishing Co
12. Day R A, *How to Write and Publish a Scientific Paper*, Cambridge University Press, 1989

13. Coley S M and Scheinberg C A, *Proposal Writing*, 1990, Newbury Sage Publications.
14. Sople, *Managing Intellectual Property: The Strategic Imperative*, Prentice Hall of India, New Delhi, 2012
15. Manna, Chakraborti, *Values and Ethics in Business Profession*, Prentice Hall of India, New Delhi, 2012.
16. Vesilind, *Engineering, Ethics and the Environment*, Cambridge University Press.
17. Wadehra, B.L. *Law relating to patents, trademarks, copyright designs and geographical indications*, Universal Law Publishing

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Overview of Research Methodology** : Research concepts, meaning, objectives, motivation, types of research, research process, criteria for good research, problems encountered by Indian researchers, scientific method, research design process.	5	15
II	**Research Problem and Design** : Formulation of research task, literature review, methods, primary and secondary sources, web as a source, browsing tools, formulation of research problems, exploration, hypothesis generation, problem solving approaches, introduction to TRIZ (TIPS), experimental research, principles, laboratory experiment, experimental designs, ex post facto research, qualitative research.	5	15
First Internal Examination			
III	**Thesis Writing, Reporting and Presentation** : Interpretation and report writing, techniques of interpretation, precautions in interpretation, significance of report writing, principles of thesis writing, format of reporting, different steps in report writing, layout and mechanics of research report, references, tables, figures, conclusions, oral presentation, preparation, making presentation, use of visual aids, effective communication, preparation for presentation in seminars and conferences.	4	15
IV	**Research proposals, Publications, Ethics and IPR** : Research proposals, development and evaluation, research paper writing, layout of a research paper, journals in engineering, considerations in publishing, scientometry, impact factor, other indexing like h-index, citations, open access publication, ethical issues, plagiarism, software for plagiarism checking, intellectual property right (IPR), patenting case studies.	5	15
Second Internal Examination			
V	**Research Methods - Modeling and Simulation** : Modeling and simulation, concepts of modeling, mathematical modeling, composite modeling, modeling with ordinary differential equations, partial differential equations (PDE), graphs, heuristics and heuristic optimization, simulation modeling.	5	20
VI	**Research Methods - Measurement, Sampling and Data Acquisition** : Measurement design, errors, validity and reliability in measurement, scaling and scale construction, sample design, sample size determination, sampling errors, data collection procedures, sources of data, data collection methods, data preparation and data analysis.	4	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EI6109	SEMINAR - 1	0 - 0 - 2 - 2	2015

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Basic knowledge in technical writing and communication skills earned through seminar at UG level.

Course Objectives

(1) To enhance the reading ability required for the literature review regarding the project work;
(2) To develop skills regarding professional communication and technical report writing.

Guidelines

The student shall prepare a paper and present a seminar on any current topic related to the branch of specialization under the guidance of a staff member. The student will undertake a detailed study based on current published papers, journals, books on the chosen subject and submit seminar report at the end of the semester. The student shall submit a printed copy of the paper to the Department. Grades will be awarded on the basis of the contents of the paper and the quality of presentation. A common format (in PDF format) shall be given for students for preparing the report. All such reports submitted by students shall be in this given format, for uniformity.

Expected Outcomes

Upon the completion of this course, students will have the ability:

- To enhance the reading ability required for the literature review
- To identify hot research topics in the relevant field
- To anayse technical problems in a critical way;
- To develop skills regarding professional communication
- To write technical reports
- To make effective power point presentation

References

1. M. Ashraf Rizvi, *Effective Technical Communication,* Tata McGraw Hill, New Delhi, 2005
2. Day R A, *How to Write and Publish a Scientific Paper,* Cambridge University Press, 1989
3. Coley S M and Scheinberg C A, *Proposal Writing,* 1990, Newbury Sage Publications.

Course plan

Item	Description	Time	
1	Abstract Submission	3 Weeks	
2	Allotment of Topic and Scheduling Seminars	2 Weeks	
3	Presentation Sessions	4 Weeks	
4	Report Submission	4 Weeks	
5	Publishing Grades	2 Weeks	

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EI6111	INDUSTRIAL INSTRUMENTATION LAB	0 - 0 - 2 - 1	2015

Course Prerequisites

Knowledge in Industrial instrumentation UG level

Course Objectives

To equip the students with the basic knowledge of pressure, temperature,flow, level,density and viscosity measurements

To understand the working of different measuring equipments.

List of Experiments

1. Measurement of temperature, level, and flow – study of characteristics of transducers and signal conditioning circuits.
2. Signal Conditioning Circuit for Temperature Measurement & Square root extractor in flow measurement – Implementation.
3. Measurement of torque, displacement, and distance – Implementation of signal conditioning circuits and study of characteristics of transducers.
4. Measuring the speed of a motor shaft with the help of non-contact type pick-ups (magnetic or photoelectric) – Implementation of a complete set-up to display the speed.
5. Use of light sensors - applications.
6. Data acquisition cards – Familiarisation of facilities – Analog i/p, analog o/p, digital i/p, digital o/p.
7. Development of virtual instrument (VI) for level measurement-with display, and visual and sound alarms
8. Development of virtual instrument (VI) for temperature measurement-with display, and visual and sound alarms
9. Developing a data logger
10. Modeling of inverted pendulum and to plot its response
11. Calibration of pressure gauges – dead weight pressure gauge
12. pH meter standardization and measurement of pH values of solutions
13. Measurements of conductivity of test solutions.
14. To test experimental data for Normal Distribution using Chi Square test.

Expected Outcomes

Upon the completion of this course, students will have the ability to:

- Attain a thorough understanding of instrumentation systems through various experiments.
- Develop measuring system for physical variables
- Develop VI systems
- Standardization and calibration of various equipments
- Design signal conditioning systems
- Familiarize with data acquisition system

References

1.Liptak B.G ,""Process measurement and analysis"",Chilton Book company,Radnor,Pennsylvania,2003.
2. A. K. Sawhney And P. Sawhney, "A Course In Mechanical Measurements And Instrumentation", Dhanpat Rai, New Delhi, 2001
3.R.K Rajput, "Mechanical measurements and instrumentation", S. K. Kataria & Sons, 2009

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6102	BIOMEDICAL INSTRUMENTATION	3-0-0- 3	2015

Course Prerequisites

Basic knowledge of **Biomedical Instrumentation** at UG Level.

Course Objectives

To have advanced level knowledge on biomedical instrumentation and its applications in medical field.

Syllabus

Fundamental of Biomedical Instrumentation – origin of bio potentials – biomedical transducers – bio signals ,ECG,EMG,EEG etc – measurement of cardiac output, blood flow, blood pressure etc – oximeters-measurements on pulmonary system – blood gas analyzers – audiometers – patient safety – lasers in medicine – X –ray applications – ultrasound in medicine – pacemakers – defibrillators – electrotherapy – hemodialysis – ventilators –radiotherapy

Expected Outcomes

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

1. Understand the human physiology systems & the origin of bio-potentials.
2. Recognize the principle operation and design and the background knowledge of biomedical instruments and specific applications of biomedical engineering
3. Understand the preprocessing of bio-signals & the blood flow measurement.
4. Depict the operation of oxymeter & X-ray
5. Identify the principle of Hemodialysis & measurement on pulmonary systems.
6. Understand importance of electrical safety in hospitals.

References

1.J. G. Webster, Biomedical Instrumentation, John Wiley and Sons, Hoboken, NJ, 2004.

2.J. Carr and J. Brown, Introduction to Biomedical Equipment Technology, Pearson Education, 2000.

3.R. S. Khandpur, Hand book of Biomedical Instrumentation, Prentice Hall of India Pvt Ltd, New Delhi, India, 1996.

4.W.J. Tomkins, Biomedical digital signal processing, PH publication, New Dehli 2004

5.Geddes & Baker , Principles of applied biomedical instrumentation Wiley Inter science , 3rd edition, 1975

6.Joseph D Bronzino, Biomedical engineering hand book, CRC Press, 2000

7.Metin Akay (editor), Wiley encyclopedia of biomedical engineering , Wiley, 2003

Module	Content	Hours	Semester Exam Marks (%)
I	Fundamentals of medical instrumentation – physiological systems of body –regulation of medical devices- biomedical transducers.	4	15
	Origin of bio potentials – Sodium –Potassium pump –Goldman Hodgkin – Katz equation – Electrode-electrolyte interface – half cell potential.	4	
II	Cardiac Pacemakers – Defibrillators-ECG – 12 lead systems – ECG-continuous monitoring, arrhythmia detection- algorithms and methods,	4	15

	HRV signal- fetal heart rate monitoring.		
	EMG – EEG- video EEG, analysis of epilepsy using EEG	3	
First Internal Examination			
III	Preprocessing of biosignals - removal of interferences due to power line & Electro Surgical Unit, Adaptive filtering.	3	15
	Measurement of cardiac output – indicator dilution method – ultrasonic blood flow meter – electromagnetic blood flow meter – blood pressure measurement.	4	
IV	Oximetry – ear oximeter – pulse oximeter –skin reflectance oximeter. Lasers in medicine – Argon laser – Carbon dioxide laser -laser safety	3	15
	X ray applications –X-ray machine – dental X-ray machine – ultra sound in medicine –electro therapy	3	
Second Internal Examination			
V	Hemodialysis – artificial kidney – dialyzers –membranes for hemodialysis.	4	20
	Measurement on pulmonary system – spirometry – pulmonary function analyzers –respiratory parameters-ventilators.	4	
VI	Measurement of p_H, pCO_2, pO_2, radiotherapy – Cobalt 60 machine.	3	20
	Medical linear accelerator machine – audiometry - electrical safety in hospitals.	3	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6104	**SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge about state space analysis, signals and systems, control theory.

Course Objectives

1. To impart concept of linear as well as nonlinear identification of system.
2. Give an insight about parametric and non-parametric identification techniques.
3. To study the role of model validation in identification.
4. To enable them to design adaptive controllers.

Syllabus

Models for Identification -Non-Parametric and Parametric Identification-Non-Linear Identification and Model Validation-Adaptive Control-Model Reference Adaptive Control (MRAC)-Case Study**.**

Expected Outcomes

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

1. Recognize various model structures.
2. Understand parametric and non-parametric modeling techniques.
3. Employ nonlinear identification techniques for their system.
4. Choose suitable adaptive control techniques.
5. Understand basic concepts of model reference adaptive control.
6. Model various test systems and develop adaptive control for it.

References

1.L. Ljung, "System Identification Theory for the User", *PHI*, 1987.
2.Arun K Tangrila, "Principles of System Identification: Theory and Practice", *Taylor and Francis*, 2015.
3.TorstenSoderstrom, PetreStoica, "System Identification", *Prentice Hall International (UK) Ltd*, 1989.
4.Astrom and Wittenmark, "Adaptive Control", *Addison and Wesley*, 1995.
5.Narendra and Annasamy, "Stable Adaptive Control Systems", *Prentice Hall*, 1989.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Models for Identification** Models of LTI systems-Linear Models-State space Models- OE model-Model sets, Structures and Identifiability.	4	15
	Models for Time-varying and Non-linear systems: Models with Nonlinearities – Non-linear state-space models-Black box models, Fuzzy models	3	
II	**Non-Parametric and Parametric Identification:** Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis	4	15
	Least Square – Recursive Least Square – Forgetting factor- Maximum Likelihood – Instrumental Variable methods.	3	
First Internal Examination			
III	**Non-Linear Identification and Model Validation:** Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification.	7	15
IV	Wiener models – Power series expansions - State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic.	7	15
Second Internal Examination			
V	**Adaptive Control:** Introduction to adaptive control – Uses –Self Tuning Regulators (STR) – Deterministic STR- Pole placement design, direct and indirect STR	4	20
	Stochastic and Predictive STR- Linear quadratic and adaptive predictive control techniques.	3	
VI	**Model Reference Adaptive Control (MRAC)** MIT Rule –design of MRAC using Lyapunov theory–Stochastic Adaptive control. Dual control- Sub optimal control - Auto tuning using transient response and relay feedback techniques– Gain Scheduling. **Case Study:**Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6106	**SCADA SYSTEMS & APPLICATIONS**	**3-1-0- 4**	**2015**

Course Prerequisites

Basic knowledge of automatic control systems, analog and digital electronics.

Course Objectives

The course is designed to develop comprehensive knowledge about application of SCADA in industrial scenario.

Syllabus

Introduction to SCADA, SCADA System Components, Communication network and technologies, SCADA Communication, Industries SCADA Applications, Case studies

Expected Outcomes

At the end of the course students will be able to

1 Identify merits and demerits of different SCADA systems.
2 Understand components of SCADA.
3 Understand various communication protocols.
4 Understand various communication methodologies.
5 Understand how SCADA applied in various industries.
6 Understand SCADA application through case studies.

References

1 Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications,USA,2004
2 Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004
3 William T. Shaw, Cybersecurity for SCADA systems, PennWell Books, 2006
4 David Bailey, Edwin Wright, Practical SCADA for industry, Newnes, 2003

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to SCADA:** Data acquisition systems, Evolution of SCADA, SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850.	8	15
II	**SCADA System Components:** Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), SCADA Server, SCADA/HMI Systems.	8	15
	First Internal Examination		
III	**Communication network and technologies**:Communication Network,Communication technologies, Monitoring and supervisory functions,. open standard communication protocols.	8	15
IV	**SCADA Communication:** various industrial communication technologies -wired and wireless methods and fiber optics. Modems	8	15
	Second Internal Examination		

V	**Industries SCADA Applications:** SCADA applications in Utility Automation, Utility applications- Transmission and Distribution sector - operations, monitoring, analysis and improvement. Industries - oil, gas and water.	8	20
VI	**Case studies**: Implementation, Simulation Exercises.	6	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L - T - P - Credits**	**Year of Introduction**
10EC6404	**ADAPTIVE SIGNAL PROCESSING**	**3 - 0- 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge of Signal processing at UG/PG Level.

(2) Basic knowledge of different transform domains like Fouries, Laplace, Z transform etc.

Course Objectives

The course is designed to provide students a strong background in the concept of signal processing and apply it to the signals which can process adaptively.

Syllabus

Adaptive systems - definitions and characteristics - applications - properties- Correlation matrix and its properties- z transform- Searching performance surface- gradient estimation - performance penalty - LMS algorithm- sequential regression algorithm - adaptive recursive filters - Kalman filters- Applications- adaptive modeling and system identification-adaptive modeling for multipath communication channel, geophysical exploration, inverse adaptive modeling, equalization, and deconvolution-adaptive equalization of telephone channels

Expected Outcomes

The students are expected to :

(1) Understand basic concepts of adaptive signal processing

(2) Top-level understanding of the convergence issues, computational complexities and

optimality of different filters

References

1.Bernard Widrow and Samuel D. stearns, "Adaptive Signal Processing", Person Education, 2005.

2.Simon Haykin, " Adaptive Filter Theory", Pearson Education, 2003.

3.John R. Treichler, C. Richard Johnson, Michael G. Larimore, "Theory and Design of Adaptive Filters",Prentice-Hall of India, 2002

4.S. Thomas Alexander, " Adaptive Signal Processing - Theory and Application", Springer-Verlag.

5.D. G. Manolokis, V. K. Ingle and S. M. Kogar, "Statistical and Adaptive Signal Processing", Mc Graw Hill International Edition, 2000.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Adaptive systems** - definitions and characteristics - applications - properties-examples - adaptive linear combiner-input signal and weight vectors, performance function, Gradient and minimum mean square error, Alternate expressions of gradient	6	15
II	**Theory of adaptation with stationary signals:** Correlation matrix and its properties, its physical significance.Eigen analysis of matrix, structure of matrix and relation with its eigen values and eigen vectors. Z Transforms in Adaptive signal processing and its applications	8	15
First Internal Examination			
III	**Searching performance surface** - stability and rate of convergence - learning curve-gradient search - Newton's method - method of steepest descent - comparison - gradient estimation - performance penalty - variance -excess MSE and time constants – misadjustments	8	15
IV	**LMS algorithm** - convergence of weight vector-LMS/Newton algorithm - properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms	8	15
Second Internal Examination			
V	**Kalman filters** - recursive minimum mean square estimation for scalar random variables- statement of Kalman filtering problem-innovation process-estimation of the state-filtering-initial conditions-	7	20

	Kalman filter as the unifying basis for RLS filters		
VI	**Applications** - adaptive modeling and system identification-adaptive modeling for multipath communication channel, geophysical exploration,inverse adaptive modeling, equalization, and deconvolution-adaptive equalization of telephone channels, Adaptive interference canceling: applications in Bio-signal processing	8	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L - T - P - Credits**	**Year of Introduction**
10EC6102	**DIGITAL IMAGE PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in DSP and Linear Algebra at UG level.
(2) Basic knowledge in data compression at UG level.

Course Objectives

(1) To extend the knowledge on DSP to 2-D signal processing and hence to analyze digital images.
(2) To study the various aspects of image processing like restoration, enhancement, compression, etc.

Syllabus

Gray scale and colour Images, image sampling, quantization and reconstruction, Human visual perception, transforms: DFT, FFT, WHT, Haar transform, KLT, DCT, Filters in spatial and frequency domains, histogram-based processing, Edge detection - non parametric and model based approaches, LOG filters, Image Restoration - PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods, Binary morphology, dilation, erosion, opening and closing, gray scale morphology, applications, thinning and shape decomposition, Image and video compression : Lossy and lossless compression, Transform based sub-band decomposition, Entropy Encoding, JPEG, JPEG2000, MPEG, Computer tomography - parallel beam projection, Radon transform, Back-projection, Fourier-slice theorem, CBP and FBP methods, Fan beam projection, Image texture analysis - co-occurrence matrix, statistical models, Hough Transform, boundary detection, chain coding, segmentation and thresholding methods.

Expected Outcomes

The students are expected to :
(1) Attain an ability to extend the one-dimensional DSP principles to two-dimension;
(2) Have good knowledge in various image processing methodologies.

References

1. A. K. Jain, *Fundamentals of digital image processing*, PHI, 1989.
2. Gonzalez and Woods, *Digital image processing* **,**3/E Prentice Hall, 2008.
3. R.M. Haralick, and L.G. Shapiro, *Computer and Robot Vision*, Addison Wesley, 1992.
4. R. Jain, R. Kasturi and B.G. Schunck, *Machine Vision*, MGH International Edition, 1995.
5. W. K. Pratt, *Digital image processing*, Prentice Hall, 1989.
6. David Forsyth & Jean Ponce, *Computer Vision: A modern approach*, Pearson Edn., 2003
7. C . M. Bishop, *Pattern Recognition & Machine Learning*, Springer 2006

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Image representation - Gray scale and colour Images, Representation of 2D signals, image sampling, quantization and reconstruction	4	15
	Two dimensional orthogonal transforms -Digital images, Human visual perception, transforms: DFT, FFT, WHT, Haar transform, KLT, DCT.	4	
II	Image enhancement - filters in spatial and frequency domains, histogram-based processing, homomorphic filtering.	4	15
	Edge detection - non parametric and model based approaches, LOG filters, localization problem.	4	
First Internal Examination			
III	Image Restoration - PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods.	4	15
	Image texture analysis - co-occurrence matrix, measures of textures, statistical models for textures. Hough Transform, boundary detection, chain coding, segmentation and thresholding methods.	4	
IV	Mathematical morphology - binary morphology, dilation, erosion, opening and closing, duality relations, gray scale morphology, applications such as hit-and-miss transform, thinning and shape decomposition.	8	15
Second Internal Examination			
V	Image and Video Compression Standards: Lossy and lossless compression schemes: Transform Based, Sub-band Decomposition, Entropy Encoding, JPEG, JPEG2000, MPEG	6	20
VI	Computer tomography - parallel beam projection, Radon transform, and its inverse, Back-projection operator, Fourier-slice theorem, CBP and FBP methods, ART, Fan beam projection.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE 6104	**CONTROL TECHNIQUES IN POWER ELECTRONICS**	**3 - 0 - 0 : 3**	**2015**

Course Prerequisites

Basic knowledge in power electronic converters and control systems at UG level.

Course Objectives

1. To have an advanced level knowledge on modeling and analysis of power electronic converters
2. To design and develop controllers for power electronics based switching circuits

Syllabus

Principles of steady state converter analysis- Steady state equivalent circuit modeling- Analysis of discontinuous conduction mode- AC modeling approach- State space averaging- Circuit averaging- Graphical construction of impedances and converter transfer function- Controller design-Measurement of ac transfer functions, impedances and loop gains- AC and DC equivalent circuit modeling of the discontinuous conduction mode- Current Programmed control

Expected Outcomes

Students who complete this course will have an ability to understand the fundamental concepts of dc and ac modeling of switching converters; have a knowledge on the impact of controllers on power electronic converters

References:

1. Robert W Erickson, Dragan Maksimovic, Fundamentals of Power Electronics 2nd Edition, Springer IN, 2005
2. Ali Emadi et.al, Integrated Power Electronic Converters and Digital Control, CRC Press, 2009

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Steady state converter analysis**: Principles of steady state converter analysis, Steady state equivalent circuit modeling, losses and efficiency- analysis of discontinuous conduction mode,	8	15
II	**AC modeling approach**: Basic AC modeling approach- small signal modeling- State space averaging- Circuit averaging and averaged switch modeling, Canonical circuit model, PWM model	6	15
	First Internal Examination		
III	**Converter transfer functions**: Review of bode plots- Analysis of converter transfer functions- Graphical construction of impedances and converter transfer function- Effect of negative feedback on the network transfer functions- Construction of Closed loop transfer functions- Measurement of AC transfer functions and impedances-	8	15
IV	**Controller design**: Stability analysis- damping factor- Phase margin- Regulator design- Lag, Lead compensator design- Measurement of loop gains	8	15
	Second Internal Examination		
V	**Discontinuous conduction mode:** AC and DC equivalent circuit modeling of the DCM- DCM averages switch model- Small signal AC modeling of DCM switch network- High frequency dynamics of converters in DCM	8	20

VI	**Current Programmed control**: Oscillations for D>0.5- First order models- Current programmed control in DCM	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EC6116	**FIBER OPTIC COMMUNICATION**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of optical fiber communication at UG Level.

Course Objectives

To develop understanding about the information necessary to understand the design, operation and capabilities of fiber systems and the fundamental concepts of various optical components.

Syllabus

Introduction, optical waveguides, modes, characteristics of optical fibres, transmitters, receivers, modulators, types, digital transmission systems, WDM base optical fiber communication system, fibre optic components.

Expected Outcomes

The students are expected to understand the basics of optical fiber communication and the latest trends in the area.

References

1. G. Keiser, “Optical Fiber Communications”, McGraw Hill, 2009.
2. G.P. Agrawal, “Nonlinear Fiber Optics”, Academic Press, 2009.
3. J.M. Senior, “Optical Fiber Communications”, Prentice Hall, India, 2008.
4. A. Selvarajan, S. Kar and T. Srinivas, *Optical Fiber Communications, Principles and Systems*, Tata-Mc Graw Hill,2002.
5. D.K. Myanbaev & Lowell L. Scheiner, “Fiber Optic Communication Technology”, Pearson Education Asia, 2008.

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction:** Optical Wave Guides- Light propagation in a linear dielectric media, Cylindrical wave guide, Boundary conditions, Cut-off frequencies, Modes, Linearly Polarised Modes, SM & MM fibers, Step Index Fiber, Graded Index Fiber. Types and classification of optical fibers.	5	15
II	**Characteristics of Optical Fibers:** Fiber Attenuation, Absorption losses, Scattering losses, Radiation losses, Bending losses, Measurement of losses, Dispersion in fibers, Effect of dispersion in communication link, Dispersion reduction and compensation techniques.	6	15

First Internal Examination			
III	**Transmitter, Receivers & Modulators:** Light emitting diodes, laser diodes, their structures, efficiency of laser diodes, functional block diagram & typical circuits of transmitter. p.i.n & A P D photodiodes noise sources in photo detectors, SNR and noise equivalent power, sensitivity & quantum limit of receivers. Functional block diagram and typical circuits of a receiver, decision circuit design, Electro- optic, electroabsorption & acousto-optic external modulators	6	15
IV	**Digital Transmission Systems:** Point to Point link, system considerations, link power, budget & rise time budget analysis. Line coding techniques, NRZ, RZ, Manchester etc. eye pattern analysis.	6	15
Second Internal Examination			
V	**WDM Base Optical Communication System:** Introduction to wavelength division multiple access. Receiver & transmitter requirements in WDM networks. Repeaters & amplifiers, Erbium doped fiber amplifier (EDFA).	3	20
VI	**Fiber Optic Components:** Couplers & splitters, splices, WDM multiplexer & demultiplexers fixed & tunable filters, isolators, circulators & attenuators. Optical switches & wavelength converters, Fiber end preparation for power launching and coupling. Recent developments and futuristic issues.	5	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6114	**PRINCIPLES OF ROBOTICS**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of matrices, vector algebra, solid geometry and sensor techniques at PG Level.

Course Objectives

To learn the general principles and terminologies of robotics, analyze the motion and velocities and apply the knowledge for various robotic applications.

Syllabus

Introduction and Terminologies-definition of robot, actuators-sensors, Kinematics, homogenous transformation-DH representation, Inverse kinematics, Differential Motion & Velocities, Jacobian, Lagrangian mechanics, Robot Control System, trajectory planning, Image Processing & Vision Systems, robots in manufacturing automation.

Expected Outcomes

After the completion of the course students will be able to:

1. Acquire knowledge about the principles of robotics.
2. Learn about the kinematics and inverse kinematics of robotics.
3. Study differential motion and velocities of robotics.
4. Analyze the control schemes used for robotics.
5. Understand the relevance of image processing and vision systems in robotics.
6. Present an overview of robotic applications.

References

1. Saeed B. Niku ,"Introduction to Robotics ", Pearson Education, 2002
2. R.K. Mittal and I J Nagrath, " Robotics and Control", Tata MacGrawHill, Fourth Reprint 2003.
3. Fu, K.S., R.C. Gonzalez, C.S.G. Lee, "Robotics: Control, Sensing, Vision & Intelligence", McGrawHill, 1987.
4. S.R Deb, "Robotics technology and flexible automation", Tata McGraw-Hill,1994.
5. Groover Mikell P., M. Weiss, R.N. Nagel, N.G. Odrey, "Industrial Robotics", McGrawHill, 1986.
6. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach", Prentice Hall of India, 2003.
7. Sciavicco, L., B. Siciliano, Modelling & Control of Robot Manipulators, 2nd Edition, Springer Verlag, 2000.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction and Terminologies:** Definition-Classification-History-Robots components-Degrees of freedom-Robot joints- coordinates-Reference frames-workspace-Robot languages.	3	15
	Sensors: Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors-proximity and range sensors.	3	
II	**Kinematics**: Mechanism-matrix representation- homogenous transformation- DH representation	3	15
	Inverse kinematics: solution and programming-degeneracy and dexterity	3	
First Internal Examination			
III	**Differential Motion & Velocities:** Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian.	4	15
	Lagrangian mechanics: Two-DOF manipulator, dynamic equations-static force analysis.	4	
IV	**Robot Control System**: Hydraulic, Pneumatic and electric actuators-trajectory planning- decentralised PID control- non-linear decoupling control.	7	15
Second Internal Examination			
V	**Image Processing:** Two and three dimensional images-spatial and frequency domain representation-noise and edges- convolution masks-Processing techniques.	4	20
	Vision Systems: Thresholding-noise reduction-edge detection-segmentation-Image analysis and object recognition.	4	
VI	**Applications:** Introduction to Intelligent Robots-Robots in manufacturing automation- material handling, welding, assembly line, inspection. Social issues.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6304	EMBEDDED SYSTEM DESIGN	3 - 0 - 0 - 3	2015

Course Prerequisites

(1) Basic knowledge in Digital Electronics at UG level
(2) Basic knowledge in Microprocessors at UG level

Course Objectives

(1) To attain a thorough knowledge in embedded systems;
(2) To develop skills in designing complex embedded systems with the help of hardware and software.

Syllabus

Terminology – Gates – Timing diagram – Memory – Microprocessor buses – Direct memory access – Interrupts – Interrupt latency - Embedded system evolution trends – Interrupt routines in an RTOS environment, System modelling with hardware/ software partitioning, Hardware/ Software Co-Design, Single & Multi Processor Architectures, Models of Computation, Requirements for Embedded System Specification, Hardware/Software Partitioning Problem, Hardware/Software Cost Estimation, Partitioning by Graphical modelling, Formulation of the HW/ SW scheduling, Optimization. Hardware/software co-synthesis, State-Transition Graph, Refinement and Controller Generation, Distributed System Co-Synthesis, Memory and interfacing : Memory write ability and storage performance – Memory types – composing memory – Advance RAM interfacing communication basic – Microprocessor interfacing I/O addressing – Interrupts, Arbitration multilevel bus architecture – Serial & Parallel protocols – Wireless protocols, Finite state machines – HCFSL and state charts language – state machine models – Concurrent process model –Synchronization among process – Implementation – Data Flow model, Design technology – Automation synthesis – Hardware software co-simulation – IP cores – Design Process Model.

Expected Outcomes

The students are expected to :
(1) Attain a thorough knowledge in embedded systems;
(2) Develop skills in designing complex embedded systems with the help of hardware and software.

References

1. David. E. Simon, “An Embedded Software Primer”, Pearson Education, 2001.
2. Tammy Noergaard, “Embedded System Architecture, A comprehensive Guide for Engineers and Programmers”, Elsevier, 2006.
3. Raj Kamal, “Embedded Systems- Architecture, Programming and Design”, Tata McGraw Hill, 2006.
4. Frank Vahid and Tony Givargis „Embedded Systems Design: A Unified Hardware/Software Introduction, John & Wiley Publications, 2002.
5. Steve Heath, “Embedded System Design”, Elsevier, Second Edition, 2004.
6. Ralf Niemann, “Hardware/Software Co-Design for Data Flow Dominated Embedded Systems”, Kluwer Academic Pub, 1998.
7. Jorgen Staunstrup, Wayne Wolf, “Hardware/Software Co-Design: Principles and Practice”, Kluwer Academic Pub, 1997.

Course plan

Module	Content	Hours	Semester Exam Marks (%)

I	Introduction to embedded hardware and software : Terminology – Gates – Timing diagram – Memory – Microprocessor buses – Direct memory access – Interrupts – Built interrupts – Interrupts basis – Shared data problems – Interrupt latency - Embedded system evolution trends – Interrupt routines in an RTOS environment.	8	15
II	System modeling - Embedded systems, Hardware/Software Co-Design, Co-Design for System Specification and modeling- Single-processor Architectures & Multi-Processor Architectures, comparison of Co-Design Approaches, Models of Computation, Requirements for Embedded System Specification	8	15
First Internal Examination			
III	Hardware/Software partitioning - Hardware/Software Partitioning Problem, Hardware/Software Cost Estimation, Generation of Partitioning by Graphical modeling, Formulation of the HW/SW scheduling, Optimization. Hardware/software co-synthesis- The Co-Synthesis Problem, State-Transition Graph, Refinement and Controller Generation, Distributed System Co-Synthesis.	8	15
IV	Memory and interfacing: Memory write ability and storage performance – Memory types – composing memory – Advance RAM interfacing communication basic – Microprocessor interfacing I/O addressing – Interrupts – Direct memory access – Arbitration multilevel bus architecture – Serial protocol – Parallel protocols – Wireless protocols – Digital camera example.	8	15
Second Internal Examination			
V	Modes of operation – Finite state machines – Models – HCFSL and state charts language – state machine models – Concurrent process model – Concurrent process – Communication among process – Synchronization among process.	6	20
VI	Implementation – Data Flow model. Design technology – Automation synthesis – Hardware software co-simulation – IP cores – Design Process Model.	6	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EI6122	**BIOPROCESS INSTRUMENTATION & CONTROL**	**3-0-0- 3**	**2015**

Course Prerequisites: Nil

Course Objectives

To gain the knowledge of different process instruments in bioprocess engineering, To understand different sensors and instrumentation systems. To understand different data processing techniques in bioprocess engineering. To design various control schemes and to study advanced control ideas for batch and continues operations.

Syllabus

Fermenters, Sensors, monitoring and control of fermenter processes, Digital computers and Data processing, Advanced control mechanisms, batch bioreactors.

Expected Outcomes

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

1.Get knowledge of field instrumentations
2.Dynamic modeling and system behavior study
3. Design controllers
4.Apply control systems in processes
5.Understand different control systems.
6.Gain knowledge about programmed batch reactions

References

1. Bailey J.E. and Ollis,D.F. " Biochemical Engineering Fundamentals" 2nd Edition, (1986), McGraw Hill Book CO.,Singapore.
2. T.K.Ghose (Ed.) "Process Computations in Biotechnology" (1994), Tata McGraw Hill Publ.Co.,N.Delhi.
3. A.Fischer (Ed.), "Advances in Biochemical Engineering," Vol. 13, 1973, Springer Verlag, Germany
4. Aiba, Humphry and Millis, " Bio Chemical Engineering ", 2nd Ed., (1973), Academic press
5. McNeil and Harvey, "Fermentation - A Practical Approach" (1990). IRL Press, U.K.
6. Scragg, "Bioreactors in Biotechnology - A Practical Approach" (1991), Ellis Horwood Ltd., U.K.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to bioprocess engineering and fermentation processes; Physical and chemical sensors;	3	15
	Biosensors; On-line sensors for cell properties ;off-line Analytical methods.	4	
II	Volumetric oxygen mass transfer coefficient in fermenters; Control of pH, control of dissolved oxygen, control of dissolved carbon dioxide, control of temperature of fermenters; Detection and prevention of foam.	7	15
First Internal Examination			
III	Elements of Digital computers; Computer Interfaces and peripheral devices; Fermentation software systems	7	15
IV	Data smoothing and interpolation; State and parameter estimation;	7	15
Second Internal Examination			
V	Direct regulatory control; cascade control of metabolism.	7	20
VI	Programmed batch bio-reaction; Design and operation strategies for batch plants; Continuous process control.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction

10EI6118	REAL TIME OPERATING SYSTEMS	3-0-0-3	2015

Course Prerequisites

Basic knowledge of Real Time Operating Systemsand it's applications at UG/PG Level.

Course Objectives

The course is designed to provide students a strong background in the concept of Operating systems used in Real time digital systems

Syllabus

Introduction to operating system, Introduction to Distributed operating systems, Overview of RTOS,Realtime models and Languages, Real time kernels, RTOS application in VOIP, image processing and control systems

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

1. Understand about realtime operating systems and it's components.
2. Describe about distributed operating system
3. Apply knowledge of RTOS in digital system design
4. Develop applications using realtime languages
5. Distinguish various RTOS
6. Outline various applications using RTOS

References

1. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Tata McGraw Hill, 2006.
2. Herma K., "Real Time Systems – Design for distributed Embedded Applications", Kluwer Academic, 1997.
3 Charles Crowley, "Operating Systems-A Design Oriented approach" McGraw Hill 1997.
4 C.M. Krishna, Kang, G.Shin, "Real Time Systems", McGraw Hill, 1997.
5. Raymond J.A.Bhur, Donald L.Bailey, "An Introduction to Real Time Systems", PHI 1999.
6. MukeshSighal and N G Shi "Advanced Concepts in Operating System", McGraw Hill 2000.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	REVIEW OF OPERATING SYSTEMS Basic Principles - Operating System structures – System Calls – Files – Processes – Design and Implementation of processes – Communication between processes	8	15
II	Introduction to Distributed operating system – Distributed scheduling.	5	15
	First Internal Examination		
III	OVERVIEW OF RTOS RTOS Task and Task state - Process Synchronization- Message queues – Mail boxes - pipes – Critical section – Semaphores – Classical synchronization problem – Deadlocks.	8	15
IV	REAL TIME MODELS AND LANGUAGES Event Based – Process Based and Graph based Models – Real Time Languages – RTOS Tasks – RT scheduling - Interrupt processing – Synchronization – Control Blocks – Memory Requirements.	8	15
	Second Internal Examination		
V	REAL TIME KERNEL Principles – Design issues – Polled Loop Systems – RTOS Porting to a Target – Comparison and study of various RTOS like QNX – VX works – PSOS – C Executive – Case studies.	8	20

VI	RTOS APPLICATION DOMAINS RTOS for Image Processing – Embedded RTOS for voice over IP – RTOS for fault Tolerant Applications – RTOS for Control Systems.	5	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L - T - P - Credits**	**Year of Introduction**
10EC6204	**DIGITAL SYSTEM DESIGN USING VHDL**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in Digital Electronics at UG level

Course Objectives

(1) To have an in depth knowledge in VHDL

(2) To understand RTL system and its design issues.

Syllabus

Introduction to VHDL: Basic language element of VHDL, Behavioral Modeling, Data flow modeling, Structural modeling, Subprograms and overloading, Execution Graph of RTL systems, Organization of System, Implementation, analysis and design of RTL Systems, Data Subsystems: Storage Modules, Functional Modules, Data paths, Control Subsystems, Micro programmed Controller, Basic component of a micro system**,** I/O subsystem: Processors, Operation of the computer and cycle time, Binary Decoder, Binary encoder, Multiplexers and Demultiplexers, Design of a Serial Adder with Accumulator, Design of a Binary Multiplier, Design of a Binary Divider. Floating Point Arithmetic-Representation of Floating Point Number, Floating Point Multiplication, Floating point Division

Expected Outcomes

The students are expected to :

(1) Have an advanced level knowledge in VHDL

(2) To throw light into the use of VHDL in design of adders, multipliers, RTL system design etc.

References

1. J. Bhaskar, “A VHDL Primer”, Addison Wesley, 1999.
2. M. Ercegovac, T. Lang and L.J. Moreno, ”Introduction to Digital Systems”, Wiley,2000
3. C. H. Roth, “Digital System Design using VHDL”, Thomson Learning,2001
4. John.F.Wakerly, “Digital Design-Principles and Practices”, PHI, 3rd Edition updated, 2005
5. Navabi, “ VHDL-Analysis and Modeling of Digital Systems”, MGH

Course plan

Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	Introduction to VHDL, Basic language element of VHDL: Identifiers, Data objects, Data types, Operators	4	15
	Behavioral Modeling, Data flow modeling, Structural modeling,	5	
	Subprograms and overloading, Packages and libraries	1	
II	**Register- transfer level systems**: Execution Graph, Organization of	1	15

	System,		
	Specification of RTL system using µVHDL, Implementation of RTL Systems, Analysis of RTL Systems, and Design of RTL Systems.	3	
First Internal Examination			
III	**Data Subsystems:** Storage Modules, Functional Modules, Data paths, Control Subsystems	2	15
	Micro programmed Controller, Structure of a micro programmed controller, Micro instruction Format, Micro instruction sequencing, Micro instruction Timing,	2	
	Basic component of a micro system, memory subsystem.	2	
IV	**I/O subsystem**: Processors, Operation of the computer and cycle time	3	15
	Binary Decoder, Binary encoder, Multiplexers and Demultiplexers	2	
Second Internal Examination			
V	**Description and design of sequential circuits using VHDL**: Design of a Serial Adder with Accumulator,	1	20
	Design of a Binary Multiplier, 4x4 Array multiplier, Multiplication of a Signed Binary Number	4	
	Design of binary divider, signed divider	4	
VI	**Floating Point Arithmetic**-Representation of Floating Point Number, Floating Point Multiplication,	4	20
	Floating point Division, floating point addition	4	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI6122	**ADVANCED TOPICS IN NON LINEAR CONTROL**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of Control Systems and Non-linear control at UG Level.

Course Objectives

The course is designed to provide students a strong understanding in the concept of Non-linear control and its implications in control theory

Syllabus

Perturbation theory, Singular perturbations, Stability analysis, Gain Scheduling, Feedback linearization, Input-output Stability, Back-stepping control algorithms.

Expected Outcomes

The students are able to

1.Apply the general principles of perturbation theory.
2.Understand concept of singular perturbations.
3.Familiarize the concepts of linearization and gain scheduling.
4.Analyze the input output stability of systems.
5.Familiarize nonlinear feedback system analysis

6.Design non-linear control algorithms.

References

1.Hasan Khalil," Nonlinear systems and control", 3rd ed, PHI
2.Slotine, J A E Slotine and W Li, "Applied Nonlinear control",1991, PHI
3.S.H. Zak," Systems and control", Oxford University Press

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Perturbation Theory:** Vanishing and Non vanishing Perturbations – Continuity of solutions on the infinite interval – Interconnected systems – Slowly varying systems – Perturbation method – Averaging - Weakly nonlinear second-order oscillators – Exercises.	8	15
II	**Singular Perturbations:**Standard singular perturbation model – Time scale properties – Singular perturbation on the infinite interval – Slow and fast manifolds – stability analysis – exercises	8	15
	First Internal Examination		
III	**Linearization :** Control problem – stabilization via linearization – integral control via linearization	5	15
	Gain Scheduling: Input output linearization – Full state linearization	4	
	Feedback Linearization: – state feedback control – tracking- exercises	5	
IV	**Input-Output Stability:** L stability – L stability of state models – L2 gain	4	15
	Second Internal Examination		
V	**Feedback system:** small gain theorem – exercises – Passivity – State models - L2 and Lyapunov stability.	4	20
VI	**Bakstepping Control Algorithms:**: Passivity based control – High gain observers – stabilization– Regulation via integral control – exercises.	4	20
	Cluster Level End Semester Examination		

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EI6108	**MINI PROJECT**	**0 - 0 - 2 - 2**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Skills in hardware/software implementation techniques earned through UG studies.
(3) Seminar I

Course Objectives

(1) To support the problem based learning approach and to enhance the reading habit among students;
(2) To enhance the skills regarding the implementation aspects of small hardware/software projects.

Guidelines

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 3rd& 4th semesters. The mini project is conceptualized in such a way that, some the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of mini project the student can suggest possible list of their thesis topic in the second semester itself. The implementation of the mini project can be software and/or

hardware based one. Mini project is envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. References cited shall be authentic.

Expected Outcomes

The students are expected to :

- Develop skills regarding enumerating and selecting hot research problems
- Develop skills for subsequent design and analysis
- Implement the hardware/software building blocks of the system
- Be motivated and successful in the selection of the topic for the main project
- Communicate in an effective way and to write technical reports
- Apply various tools for the analysis of the results and performance of the work.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
1	Abstract Submission	2 Week	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

Course No.	Course Name	L-T-P-Credits
10EI6112	**PROCESS CONTROL LAB**	**0-0-2-1**

Course Prerequisites

Knowledge in Control system at UG level

Course Objectives

To understand the functioning of different controller scheme

To implement various processes in different environments like MATLAB, LabVIEW etc

List of experiments

1.Temperature, flow, and level control using P, PI, PD, and PID controllers–Comparison and study of output responses of each process.

2.Control of a water level using LABVIEW DAQ card

3.Controller Tuning using Ziegler-Nichols and Cohen and Coon rules-for temperature and level processes

4.PLC-ladder diagram implementation and control of industrial control systems.

5. Using MODBUS or other communication protocol for Process Control

6. Experimentation of Control loops for Inverted Pendulum

7. Simulation of feed-forward, cascade, and ratio controls using suitable software.

8. Experimental Study of DCS and SCADA in a process control system.

9. Study of performance and automation of a flexible manufacturing trainer

10. PC based control of robotic actions or similar systems

11. Computation of time response - analysis of stability, controllability, and observability – using suitable computing software

12. Study of calibration of process instruments like one using a HART calibrator.

13. Study of control valve characteristics using inputs from LABVIEW and DAQ interface.

14. Design and simulation of regulator systems

15. Liquid Level Control of Multi Tank System

16. Use of Matlab for controlled system design, simulation and performance evaluation

Expected Outcomes

Upon the completion of this course, students will have the ability to:

- Attain a thorough understanding of process control systems through various experiments.
- Implement various control schemes
- Develop PID controllers for physical systems
- Simulate process control systems in MATLAB platform
- Develop process control systems in LabView platform
- Familiarize with various internet protocol systems

References

1. Curtis Johnson, “Process control Instrumentation Technology”, Prentice Hall of India Pvt. Ltd, 2001

2. Donald R. Coughanowr, “Process Systems Analysis & Control”, McGraw-Hill Inc., 1991.

3. Wayne Bequette,“Process control, Modelling, simulation & Control”, PHI Pvt. Ltd, 2004.

4. Stephanopoulis, G, “Chemical Process Control”, Prentice Hall of India, New Delhi, 1990.

5. Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes, 2000.

Assessment

i) Practical Records /outputs- 40%

ii) Regular Class Viva-Voce- 20%

iii) Final Test(Objective)- 40%

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7105	**AUDIO PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in data compression and multimedia at UG level;

(2) Knowledge in Digital Signal Processing at PG level.

Course Objectives

(1) To apply the theoretical knowledge in DSP to audio processing;

(2) To have a good foundation in speech modeling, coding and compression.

Syllabus

Digital models for the speech signal - mechanism of speech production - acoustic theory - lossless tube models - digital models - linear prediction of speech - auto correlation - formulation of LPC equation, Spectral analysis of speech - Short Time Fourier analysis - filter bank design. Auditory Perception : Psychoacoustics- Speech coding - sub-band coding of speech - transform coding - channel vocoder - formant vocoder - cepstralvocoder - homomorphic speech processing - homomorphic systems for convolution - complex cepstrums - Speech Transformations - Time Scale Modification - Voice Morphing. Automatic speech recognition systems - isolated word recognition - connected word recognition -large vocabulary word recognition systems - pattern classification - Audio Processing : Non speech and Music Signals - Modeling -Differential, transform and subband coding of audio signals & standards - Audio Data bases and applications - Content based retrieval.

Expected Outcomes

The students are expected to :

(1) Have the ability to apply the theoretical knowledge in DSP to audio processing;

(2) To have a good foundation in speech modeling, coding and compression.

References

1. Rabiner L.R. & Schafer R.W., “Digital Processing of Speech Signals”, Prentice Hall Inc.
2. O'Shaughnessy, D. “Speech Communication, Human and Machine”. Addison-Wesley.
3. Thomas F. Quatieri , “Discrete-time Speech Signal Processing: Principles and Practice” PH.

4. Deller, J., J. Proakis, and J. Hansen. “Discrete-Time Processing of Speech Signals.” Macmillan.
5. Ben Gold & Nelson Morgan , “ Speech and Audio Signal Processing”, John Wiley & Sons, Inc.
6. Saito S. & Nakata K., “Fundamentals of Speech Signal Processing”, Academic Press, Inc.
7. Papamichalis P.E., “Practical Approaches to Speech Coding”, Texas Instruments, Prentice Hall
8. Jayant, N. S. and P. Noll. “Digital Coding of Waveforms: Principles and Applications to Speech and Video. Signal Processing Series”, Englewood Cliffs: Prentice-Hall.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Digital models for the speech signal - mechanism of speech production - acoustic theory - lossless tube models - digital models - linear prediction of speech - auto correlation - formulation of LPC equation - solution of LPC equations - Levinson Durbin algorithm - Levinson recursion - Schur algorithm - lattice formulations and solutions - PARCOR coefficients	8	15
II	Spectral analysis of speech - Short Time Fourier analysis - filter bank design. Auditory Perception : Psychoacoustics- Frequency Analysis and Critical Bands - Masking properties of human ear.	6	15
First Internal Examination			
III	Speech coding -subband coding of speech - transform coding - channel vocoder - formant vocoder - cepstralvocoder - vector quantizer coder- Linear predictive Coder. Speech synthesis - pitch extraction algorithms - gold Rabiner pitch trackers - autocorrelation pitch trackers - voice/unvoiced detection - homomorphic speech processing - homomorphic systems for convolution - complex cepstrums - pitch extraction using homomorphic speech processing. Sound Mixtures and Separation - CASA, ICA & Model based separation.	8	15
IV	Speech Transformations - Time Scale Modification - Voice Morphing. Automatic speech recognition systems - isolated word recognition - connected word recognition -large vocabulary word recognition systems - pattern classification - DTW, HMM - speaker recognition systems - speaker verification systems - speaker identification Systems.	8	15
Second Internal Examination			
V	Audio Processing : Non speech and Music Signals - Modeling - Differential, transform and subband coding of audio signals & standards - High Quality Audio coding using Psychoacoustic models - MPEG Audio coding standard.	6	20

VI	Music Production - sequence of steps in a bowed string instrument - Frequency response measurement of the bridge of a violin. Audio Data bases and applications - Content based retrieval.	6	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EI7105	**OPTIMAL CONTROL THEORY**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge about optimization, Control system, Calculus.

Course Objectives

1. To provide a basicunderstanding about the concept of optimization used in control systems.
2. To discusses various methods of dynamic programming.
   Impart knowledge on calculus of variations and variational approach for control problems.
3. To give an insight on various numerical techniques.

Syllabus

Introduction to optimal control, Problem formulation, Different Form of optimal control, Dynamic Programming, Calculus of variations, Variational approach to optimal control problems, Numerical determination of optimal trajectories, Numerical Techniques For Optimal Control.

Expected Outcomes

At the end of the course students will be able to

1. Formulate and categorize an optimal control problem.
2. Devise an optimal control by dynamic programming.
3 Understand the concept of calculus of variations method.
4 Apply variational approach to optimal control problem.
5 Solve minimum control effort problems.
6 Use numerial techniques to solve control problems.

References

1.Donald E. Kirk, Optimal Control Theory: An Introduction, Prentice-Hall networks series, 1970.

2.Anderson .B. D. O, Moore .J. B, Optimal control linear Quadratic methods, Prentice Hall of India, 1991.

3.Sage A. P, White .C. C, Optimum Systems Control, Second Edition, Prentice Hall, 1977.

Course Plan

Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	Problem formulation – Mathematical model – Physical constraints – Performance measure Optimalcontrol problem.	4	15
	Form of optimal control-Performance measures for optimal control problem.Selection a performance measure.	3	
II	Dynamic Programming – Optimal control law – Principle of optimality. Arecurrence relation of dynamic programming – computational procedure. Characteristics ofdynamic programming solution.	4	15
	Hamilton – Jacobi – Bellman equation. Continuous linear	3	

	regulatorproblems.		
First Internal Examination			
III	Calculus of variations – Fundamental concepts. Functionals. Piecewise – smooth extremals. Constrained extrema.	7	15
IV	Variational approach to optimal control problems – Necessary conditions for optimal control –Linear regulator problems. Linear tracking problems. Pontryagin's minimum principle and stateinequality constraints.	7	15
Second Internal Examination			
V	Minimum time problems – Minimum control – effort problems. Singular intervals in optimal controlproblems.	4	20
	Numerical determination of optimal trajectories – Two point boundary – value problems.	3	
VI	Numerical Techniques For Optimal ControlMethods of steepest decent, variation of extremals. Quasilinearization. Gradient projection algorithm.	4	20
	Fletcher Powell method solution of Ricatti equation by negative exponential and interactive Methods.	3	
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EC7207	**MICRO ELECTRO MECHANICAL SYSTEMS**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of electronic and mechanical components at UG/PG Level.

Course Objectives

The course is designed to provide students a strong background and fundamental basis of MEMS and devices, such as microactuators and microsensors, as well as their principles of operation.

Syllabus

Overview Of Mems, Micro Fabrications And Micromachining, Physical Microsensors, Micro Actuators, Case Studies

Expected Outcomes

The students are expected to apply working principles of currently available microsensors, actuators, microsystem conceptual design of microdevices and systems.

References

1. Marc Madou, "Fundamentals of Microfabrication", CRC press 1997.

2. Stephen D. Senturia," Micro system Design", Kluwer Academic Publishers,2001

3. B.H. Bao, "Analysis and design principles of MEMS Devices", Elsevier, 2005.

4. Tai Ran Hsu ,"MEMS and Microsystems Design and Manufacture" ,Tata McGraw Hill, 2002.

5. Chang Liu, "Foundations of MEMS", Pearson education India limited, 2006

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Overview Of Mems:- History of MEMS, MEMS and Microsystems, Scaling laws in Miniaturization. Materials for MEMS and Microsystems.	8	15
II	Micro Fabrications And Micromachining: Microsystem Design and Fabrication, Microsystem fabrication processes- Photolithography, Ion Implantation, Diffusion, Oxidation	4	15
	Chemical and Physical Vapor deposition, Deposition by Epitaxy, Etching. Bulk Micro manufacturing, Surface micromachining, LIGA process.	4	
First Internal Examination			
III	Physical Microsensors: Design of Acoustic wave sensors, resonant sensor,Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors	8	15
IV	Microsensors**:**Engineering mechanics behind these Micro sensors.	8	15
Second Internal Examination			
V	Microactuators: Design of Actuator, Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals.	4	20
	Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps.	4	
VI	Case Studies Ink jet pointer heads, Micro mirror TV Projector, DNA chip, Micro arrays, and RF electronic devices.	4	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7507	**SOFT COMPUTING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

Concepts of Classical Set Theory, Probability and Statistics

Course Objectives

To give the Student:-

1. An overview of various Soft Computing techniques
2. Its application to solve various engineering problems in their stream of study

Syllabus

Fuzzy Logic, Genetic Algorithms, Neural networks, Hybrid Systems, Applications

Expected Outcomes

Through this course, a student will be able to comprehend the underlying principles of various soft computing techniques and its application in VLSI and Signal processing applications.

References

1. Jang, Sun and Mizutani; *Neuro-Fuzzy and Soft-Computing* , A computational approach to learning and machine intelligence; Prentice Hall of India
2. T.J. Ross, *Fuzzy Logic with Engineering Application*, John Wiley and Sons, 2004.
3. Klir & Yuan, Fuzzy Sets & Fuzzy Logic, PHI
4. Goldberg David E., Genetic Algorithm, Pearson
5. S. Haykin, *Neural Networks: A Comprehensive Foundation*, Pearson, 2006
6. S.N. Sivanandam, S.N. Deepa, *Principles of Soft Computing*, Wiley India 2008.
7. Pinaki Mazumder, Elizabeth M. Rudnick, *Genetic Algorithms for VLSI Design, Layout and Test Automation*, LPE, Pearson Education

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Fuzzy Logic- Introduction, Fuzzy Logic: Fuzzy Set operations, Fuzzy Rules, Extension Principle, Fuzzy relations, Fuzzy compositions, Fuzzy Inference Systems, Fuzzy Models, Defuzzification methods.	6	15
II	Genetic Algorithms- Fitness function, Selection of initial population, Cross over, Mutation, Inversion, Deletion, reproduction; Schema theorem, Optimization in GA. (Assignment 1: Software simulation of Fuzzy and Genetic algorithm)	8	15
First Internal Examination			
III	Neural Networks I : Basic-concepts, single layer perception, application to linearly separable problems, Multi-layer perception, RBF and Cover's theorem.	6	15
IV	Neural Networks II: Adaptive networks, Back propagation, Steepest Descent, LSE, Learning from Reinforcement, Competitive Learning networks, Kohonen Self Organizing Maps, Learning vector Quantization, Hebbian Learning, Principal Component Networks, Hopfield Networks	8	15
Second Internal Examination			

V	Hybrid Systems:- ANFIS, Fuzzy Filtered NN, Data Clustering algorithms, Genetic Algorithm--based Fuzzy Filters	6	20
VI	Application: Printed Character Recognition, Channel Equalization, Adaptive Noise Cancellation, Inverse Pendulum and its application, Application in VLSI Circuit Partioning (Assignment 3: Case study of application of Soft Computing technique in the selected branch of study)	8	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EI7107	**DIGITAL CONTROL SYSTEMS DESIGN**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of Control system theory at UG Level.

Course Objectives

The course is designed to provide students a strong background in the concept and analysis of control system theory in discrete domain.

Syllabus

Introduction to discrete domain, State space representation and analysis in discrete domain, State observation, State control, State feedback. Full order and lower order observers, Pole placement, Ideal tracking system design.

Expected Outcomes

The students areable to

- Apply the general concepts of control systems in discrete domain
- Understand the concept of state space representation of systems
- Familiarize the concept of state observability and controllability
- Design state feedback controllers
- Design Ideal model tracking systems
- Analyze system stability and design controlled systems.

References

1. Gene H. Hostetter, Digital Control System, Second Edition Holt,Rinehart and Winston, Inc.U.S, 1997
2. Ogata K, Discrete Time Control Systems, Pearson Education, 2001.
3. Gopal M, Digital Control and State variable Methods, Second Edition, Tata McGrawHill, New Delhi, 2003.

Course Plan

Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	**Introduction to discrete domain:** Discrete time signals, Discrete time systems, Sampling and reconstruction, digitizing analogcontrollers.	8	15
II	**State space representation and analysis in discrete domain:**Discrete	6	15

	time state equations, discrete time system response, the characteristic value problem,Uncoupling state equations, Observability and controllability.		
First Internal Examination			
III	**State observation:** Observability and state observation, Estimation and identification.	4	15
	State Control: Controllability and state control,State feedback, Output feedback.	4	
IV	**State feedback control design:** Full order state observer, Observer design, Lower-order observers, Eigenvalue placement with observer feedback.	6	15
Second Internal Examination			
V	**Ideal tracking system design:** Ideal tracking system design, Response model tracking system design, Reference model trackingsystem design.	6	20
VI	**Pole Placement design:** Introduction, Basic concepts, State regulator design **Lyapunov stability Analysis:**Basic concepts, Asymptotic stability, Conditions of stability, Stability analysis.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7113	**PATTERN RECOGNITION**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in probability and linear algebra at UG level;

(2) Basic knowledge in digital signal processing at UG level.

Course Objectives

(1) To apply the theoretical knowledge in probability, linear algebra and DSP to pattern recognition;

(2) To have a good foundation in methods for feature selection, classification and clustering.

Syllabus

Features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition, Classifiers based on Bayes Decision theory- Linear classifiers,- Linear discriminant functions and decision hyper planes, The perceptron algorithm, MSE estimation, Support Vector Machines (SVM), Non-Linear classifiers - Two layer and three layer perceptrons, Back propagation algorithm, Radial Basis function

networks, Decision trees, combining classifiers, Receiver Operating Characteristics (ROC) curve, Class separability measures, Feature Generation - Linear transforms - KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transform, Regional features, features for shape and characterization, Fractals, Context dependent classification, HMM, Viterbi Algorithm. System evaluation, Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Neural Network implementation., Agglomerative algorithms, Divisive algorithms, Fuzzy clustering algorithms, Probabilistic clustering, K-means algorithm, Clustering algorithms based on graph theory, Binary Morphology Clustering Algorithms, Boundary detection methods.

Expected Outcomes

The students are expected to :

(1) Apply the theoretical knowledge in probability, linear algebra and DSP to pattern recognition;

(2) To have a good foundation in methods for feature selection, classification and clustering.

References

1. Sergios Theodoridis, Konstantinos Koutroumbas, *Pattern Recognition*, Academic Press, 2006.
2. Duda and Hart P.E, *Pattern classification and scene analysis*, John Wiley and sons, NY, 1973.
3. E. Gose, R. Johnsonbaugh, and S. Jost, *Pattern Recognition and Image Analysis*, PHI, 1999.
4. Fu K.S., Syntactic *Pattern recognition and applications*, Prentice Hall, Eaglewood cliffs, N.J., 1982.
5. R. O. Duda, P. E. Hart and D. G. Stork, *Pattern classification*, John Wiley & Sons Inc., 2001.
6. Andrew R. Webb, *Statistical Pattern Recognition*, John Wiley & Sons, 2002.
7. D. Maltoni, D Maio, AK Jain, S Prabhakar, Handbook of Fingerprint Verification, Springer Verlag, 2003.
8. S. Â Kung, M. Â Mak, S.Â Lin, Biometric Authentication: A Machine Learning Approach, PH PTR, 2004.
9. Paul Reid, *Introduction to Biometrics and Network Security*, Prentice Hall PTR, 2004.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition. Classifiers based on Bayes Decision theory- introduction, discriminant functions and decision surfaces, Bayesian classification for normal distributions, Estimation of unknown probability density functions, the nearest neighbour rule.	8	15
II	Linear classifiers,- Linear discriminant functions and decision hyper planes, The perceptron algorithm, MSE estimation, Logistic determination, Support Vector Machines (SVM).	6	15
First Internal Examination			

III	Non-Linear classifiers - Two layer and three layer perceptrons, Back propagation algorithm, Networks with Weight sharing, Polynomial classifiers, Radial Basis function networks, Support Vector machines-nonlinear case, Decision trees, combining classifiers, Feature selection, Receiver Operating Characteristics (ROC) curve, Class separability measures, Optimal feature generation, The Bayesian information criterion.	8	15
IV	Feature Generation - Linear transforms - KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transform, Wavelet Packets - 2-D generalizations - Applications. Regional features, features for shape and characterization, Fractals, typical features for speech and audio classification, Template Matching, Context dependent classification - Bayes classification, Markov chain models, HMM, Viterbi Algorithm. System evaluation - Error counting approach, Exploiting the finite size of the data.	8	15
Second Internal Examination			
V	Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Neural Network implementation. Hierarchical algorithms - Agglomerative algorithms, Divisive algorithms. Schemes based on function optimization - Fuzzy clustering algorithms, Probabilistic clustering, K-means algorithm.	8	20
VI	Clustering algorithms based on graph theory, Competitive learning algorithms, Binary Morphology Clustering Algorithms, Boundary detection methods, Valley seeking clustering, Kernel clustering methods. Clustering validity.	6	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EI7111	**MICROCONTROLLER BASED SYSTEM DESIGN**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of mathematics, sciences and engineering in UG level.

Course Objectives

The course is designed to provide students a strong background in the architecture of microcontrollers ,peripherals ,microcontroller programming , design and interfacing of microcontroller-based embedded systems.

Syllabus

Introduction to Microcontroller, architecture, detailed description about peripherals used ,8051and PIC microcontroller architecture ,instruction set, programming ,system design

Expected Outcomes

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

1.Define microprocessor,microcontroller ,recognise its periherals on chip programming.
2.Explain the architecture of the 8051
3.Write the assembly programming for 8051 .
4. Explain the architecture of PIC microcontroller.
5. Write the assembly programming for the PIC microcontroller and its peripherals.
6.Design the systems such as LCD ,keypad interfacing ,gate signal generators for inverters and converters ,motor control and data acquisition system.

References

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ' PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education 2008
2. John Iovine, 'PIC Microcontroller Project Book ', McGraw Hill 2000
3. Myke Predko, "Programming and customizing the 8051 microcontroller", Tata McGraw Hill 2001.
4. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, 'The 8051 Microcontroller and Embedded Systems' Prentice Hall, 2005.
5. Rajkamal,".Microcontrollers-Architecture,Programming,Interfacing & System Design",2ed,Pearson,2012.
6. I Scott Mackenzie and Raphael C.W. Phan, "The Micro controller", Pearson, Fourth edition 2012

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	INTRODUCTION:Introduction to Embedded System.Microprocessor vs Microcontroller.CISC vs RISC. Overview of Architecture of ATMEGA16: On-Chip Peripherals Study, External Interfaces Study. Protocols Study	4	15
	Low Level programming Concepts, Middle Level Programming Concepts, On-Chip Peripherals Study Programming, and Application-Ports: Input/Output Timers & Counters, UART Interrupts	4	
II	8051 ARCHITECTURE :Architecture – memory organization – addressing modes – instruction set	4	15
	Timers -Interrupts - I/O ports, Interfacing I/O Devices – Serial Communication	3	
	First Internal Examination		
III	8051 PROGRAMMING Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming	3	15
	Serial Communication Programming-Interrupt Programming – RTOS for 8051 – RTOS Lite – FullRTOS – Task creation and run – LCD digital clock/thermometer using Full RTOS	4	
IV	PIC MICROCONTROLLER Architecture – memory organization – addressing modes – instruction set	3	15

	PIC programming in Assembly & C I/O port, Data Conversion, RAM & ROM Allocation, Timer Programming	4	
Second Internal Examination			
V	PERIPHERAL OF PIC MICROCONTROLLER Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules	3	20
	ADC, DAC and Sensor Interfacing –Flash and EEPROM memories	3	
VI	SYSTEM DESIGN – CASE STUDY Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters	4	20
	Motor Control – Controlling DC/ AC appliances, Measurement of frequency - Stand alone Data Acquisition System	3	
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P-Credits**	**Year of Introduction**
10EI7113	**PIPING AND INSTRUMENTATION**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of different industrial equipment at UG Level.

Course Objectives

To familiarize students about various P&ID diagrams and their implementation and application

Syllabus

Flow sheets types and presentation - P & I D objectives- P & I D development stages—control system for different industrial equipment- Applications of P & I D

Expected Outcomes

Students will be able to :-

- Understand different types of flow sheets
- Understand the rules and regulations of P&ID
- Understand design stage application of P&ID
- Study the P&ID design for different types of industrial equipment
- Analyze the risk involved in their application.
- Design flow sheets for their application.

References

1. *Ernest E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", Vol.-I Gulf Publishing Company, Houston, 1989.*
2. *Max. S. Peters and K.D.Timmerhaus, "Plant Design and Economics for Chemical Engineers",McGraw Hill, Inc., New York, 1991.*
3. *Anil Kumar,"Chemical Process Synthesis and Engineering Design", Tata McGraw Hill publishing Company Limited, New Delhi - 1981.*
4. *A.N. Westerberg, et al., "Process Flowsheeting", Cambridge University Press, 1979.*

Module	Content	Hours	Semester Exam Marks (%)
I	Types of flow sheets, Flow sheet Presentation, Flow Sheet Symbols.	4	15
	Process flow diagram - Synthesis of steady state flow sheet - Flow sheeting software.	4	
II	P & I D objectives, guide rules, Symbols	4	15
	Line numbering, Line schedule in P & I D	4	
First Internal Examination			
III	P & I D development, typical stages of P & I D.	3	15
IV	P & I D for rotating equipment and static pressure vessels, Process vessels, absorber, evaporator.	5	15
Second Internal Examination			
V	Control System for Heater, Heat exchangers, reactors.	5	20
	Dryers, Distillation column, Expander.	4	
VI	Applications of P & I D in design stage - Construction stage Commissioning stage - Operating stage- Revamping stage	4	20
	Applications of P & I D in HAZOPS and Risk analysis	5	
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EI7101	**SEMINAR – II**	**0 - 0 - 2**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings, journals etc.

(2) Knowledge in technical writing and communication skills earned through seminar at UG level and in first semester

(3)The course Seminar I in first semester

Course Objectives

(1) To enhance the reading ability required for identification of the thesis area and its literature review

(2) To develop skills regarding professional communication and technical report writing.

(3) To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.

(4) To arrive at a conclusion for doing Project Phase 1;

(5) To learn how to prepare and publish technical papers.

Guidelines

Students have to present a second seminar in 3rd semester. It is highly recommended that seminar-2 may report the literature survey being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized at the end of the second semester/ in the beginning of the 3rd semester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress Evaluation Committee (PEC) formed in the second semester itself, may be the panel of evaluators for Seminar-2 also. The presentation of seminar-2 shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended that the report for seminar-2 may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper. This makes a student learn how to publish a paper and consequently develops a publishing culture among the PG student community. The references cited in the report shall be *authentic*.

Expected Outcomes

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

(1) Be motivated in reading which equip them in identification of thesis area and its literature review;

(2) Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction;

(3) Develop skills regarding professional communication and oral presentation;

(4) Arrive at a conclusion for doing Project Phase 1;

(5) Develop skills for technical report writing

(6) Learn the methodology of publishing technical papers.

References

1.M. Ashraf Rizvi, *Effective Technical Communication*, Tata McGraw Hill, New Delhi, 2005

2.Day R A, *How to Write and Publish a Scientific Paper*, Cambridge University Press, 1989

3.Coley S M and Scheinberg C A, *Proposal Writing*, 1990, Newbury Sage Publications.

Course plan

Item	Description	Time	
1	Abstract Submission 3 Weeks	3 Weeks	

2	Allotment of Topic and Scheduling Seminars	1 Weeks	
3	Literature Review and Presentation Sessions	6 Weeks	
4	Report Submission	3 Weeks	
5	Publishing Grades	1 Weeks	

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EI7103	**PROJECT(PHASE I)**	**0 - 0 - 12**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest solving in socially relevant or research problems
(3) Skills in hardware/software implementation techniques earned from UG and mini project in semester 1
(4) Course Mini project, Seminar II &b Research Methodology

Course Objectives

(1). The student is expected to finalise the thesis topic from the areas identified during seminar II. Background studies towards the project have to be done through literature survey in relevant fields.
(2). (S)he will work on the topic, familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work.
(3) To develop the skill of identifying research problems/socially relevant projects
(4) To enhance the skills regarding the implementation aspects of small hardware/software projects.

Guidelines

Each student has to identify the topic project (phase I) related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 4th semester also. This project phase is conceptualized in such a way that, some the outcomes of the work may be continued for thesis work. Hence on completion of thisproject phase, (S)he will make a presentation based on the work and suggest future plan for his thesis work. The implementation of this phase of project can be software and/or hardware based one. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*.References cited shall be authentic.The following guidelines also have to be followed.

1. The student will submit a detailed project (phase I)report
2. The student will present at least two seminars
3. The first seminar will highlight the topic, objectives and methodology
4. A progress seminar can be conducted in the middle of the semester
5. The third seminar will be a presentation of the work they have completed till the end of third semester and the scope of the work which is to be accomplished in the fourth semester, mentioning the expected results

Expected Outcomes

The students are expected to :
(1) Develop the skill of identifying industrial/ research problems/socially relevant projects

(2) Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution.
(3) Hands on experience in design and analysis tools required for the project work
(4)Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning
(5) To enhance the skills regarding the implementation aspects of hardware/software projects.
(6) Acquire documentation and problem solving skills.
(7) Develop professionalism.
(8) Communicate technical information by means of written and oral reports.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments*, Wiley International
4. Leedy P D, *Practical Research : Planning and Design*, 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
1	Abstract Submission	2 Week	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EI7104	**PROJECT (PHASE II)**	**0 - 0 – 22**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest solving in socially relevant or research problems
(3) Skills in hardware/software implementation techniques earned from UG and mini project in semester 1
(4) Course Seminar II&b Research Methodology
(5) Course PROJECT(Phase I)

Course Objectives

(1) It is expected to complete the thesis work, which is normally based on Project (phase I)
(2)To work on the topic, and get the result.
(3) To develop the skill of achieving specific research target in a limited time
(4) To implement/completethe thesis work

Guidelines

Each student has to complete project (phase II) under the guidance of a faculty member, as specified in Phase I. It has to be approved by a committee constituted by the institute concerned. Hence on completion of this project phase, (S)he will make a presentation based on the work and suggest future possibilities. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a

student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. References cited shall be authentic.

The following guidelines also have to be followed.

1. The student will submit a detailed project (phase II)report
2. The student will present at least three seminars
3. The first seminar will highlight the topic, objectives and methodology
4. A progress seminar can be conducted in the middle of the semester
5. The third seminar (pre submission seminar) will be a presentation of the work they have completed till the end of forth semester and scope for future work also has to be mentioned.The pre-Submission seminar has to be presented before the Evaluation Committee for assessing the quality and quantum of work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of Thesis.

Expected Outcomes

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

(1) Develop the skill of identifying industrial/research problems/socially relevant projects
(2) (2)Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution.
(3) Hands on experience in design and analysis tools required for the project work
(4) Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning
(5) Enhance the skills regarding the implementation aspects of hardware/software projects.
(6) Acquire documentation and problem solving skills.
(7) Develop professionalism.
(8) Communicate technical information by means of written and oral reports.

References

1.J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2.Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3.Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4.Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
(1)	Implementation Phase	10 Weeks	
(2)	Thesis Preparation	3 Weeks	
(3)	Final Internal Presentation-cum Demonstration	1 Week	
(4)	Evaluation by the External expert	4 Weeks	

ASSESSMENT CRITERIA

A. Evaluation of Theory Courses

KTU follows a continuous academic evaluation procedure. This includes two internal examinations and one end semester cluster level University examination. Besides, students should be given proper assignments / course seminars which are essential aspects of a student-centric teaching approach. The continuous assessment procedure and corresponding weights for awarding 100 marks for a theory subject are as follows.

1. Two internal tests, each having 15 marks summing to a total of 30 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
3. Cluster level end-semester examination having 60 marks

B. Evaluation of Research Methodology

The course Research Methodology should be a common one for all specializations, which is envisaged to provide a research orientation for PG students. The teaching - learning process for this course should be a student-centric one in which the faculty-in-charge would take the role of a facilitator in the system. Students should be given proper guidelines for practicing the various methodologies which aims at the overall improvement of their skills required for pursuing research. The continuous assessment procedure and corresponding weights for awarding 100 marks (fully internal) for Research Methodology are as follows.

1. Two internal tests, each having 30 marks summing to a total of 60 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 40 marks

C. Evaluation of Practical Courses

The continuous assessment procedure and corresponding weights for awarding 100 marks for a practical subject are as follows.

1. Practical Records / Results summing to a total of 40 Marks
2. Regular Class Viva-Voce summing to a total of 20 Marks
3. Final Test (Internal & Objective Type) having 40 Marks

D. Guidelines for Seminar-1

Students have to select a topic and present a seminar in first semester on any current topic related to the branch of specialization under the guidance of a faculty member. It is recommended that the same faculty member may serve as his/her supervisor for the mini-project in 2nd semester and also for the main project during 3rd& 4th semesters. Hence it is also recommended that a topic, possibly relevant to his mini-cum-main project may be selected as the topic for seminar-1, after the consultation with the guide. The student will undertake a detailed study of the subject based on current published papers, journals, and books and present it before a committee with the Head of the Department as the chairman and two faculty members (Faculty advisor + Guide) from the department as members. The presentation shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, coverage of

the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution.

The weights for awarding 100 marks (totally internal) for the seminar-1 is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the topic (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report in the prescribed format given by the Institution : 30 marks

E. Guidelines for the Mini Project

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 3rd& 4th semesters. The mini project is conceptualized in such a way that, some the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of mini project the student can suggest possible list of their thesis topic in the second semester itself. The implementation of the mini project can be software and/or hardware based one. Mini project is envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning* strategy.

There should be a Progress Evaluation Committee (PEC) for each student which is constituted by three faculty members : (1) HoD as chairman, (2) Faculty advisor, and (3) Guide. This committee should evaluate the mini project through 2 presentations - (i) a preliminary presentation which is to be held soon after finalizing the topic, and (ii) a final presentation towards the end of the semester. In between, the Guide and /or the Co-guide is entrusted for the continuous evaluation of the work progress.

The weights for awarding 100 marks (totally internal) is as follows.

(1) Preliminary Presentation (PEC) : 20 Marks

(2) Progress Evaluation (Guide and/or Co-guide) : 30 Marks

(3) Final Presentation-cum-demonstration (PEC): 30 Marks

(4) Report (Mandatory) : 20 Marks

F. Guidelines for Seminar-2

Students have to present a second seminar in 3rd semester. It is highly recommended that seminar-2 may report the *literature survey* being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized in the beginning of the 3rd semester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress evaluation Committee (PEC) formed in the second semester itself, will be the panel of evaluators for Seminar-2 also. The presentation of seminar-2 shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended that the report for seminar-2 may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper. This makes a student learn how to publish a paper and consequently develops a publishing culture among the PG student community.

The weights for awarding 100 marks (totally internal) for the seminar-2 is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the literature review (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report / Paper in the prescribed format given by the Institution : 30 marks

G. Guidelines for the Project Work

Project work is to be carried out in the 3rd and 4th semesters and also to be evaluated in both semesters. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in the 4th semester, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the Head of Institution before taking up external project work. Project evaluation committee should study the feasibility of each project work before giving consent. The project work is also to be evaluated continuously, during 3rd & 4th semesters through presentation sessions. Based on these evaluations the grade is finalized in the fourth semester. The internal committee (PEC) and an External Expert shall evaluate the project based on *four* presentations by the student during these semesters. The *first* presentation in 3rd semester should be held in the beginning of the semester which would highlight the topic, objectives, and the methodology. The *second* presentation in the same semester should bring out the work progress through the preliminary results and is to be conducted towards the end of the semester. These are evaluated totally internally by the PEC.

The Project Phase - II will be an extension of the Project Phase - I. A student has to prepare a project report, namely the thesis, towards the end of the 4th semester. Both the presentation and the thesis will be evaluated by the Committee and the External expert. The *third* presentation on project is to be made towards the end of 4th semester as a final internal presentation. At least one technical paper is to be published in Journals / Conferences so as to meet the requirements for final external submission. The *fourth* presentation is a *repetition* of the third one, but before an *External Expert*, appointed through the process of submitting the M. Tech. Thesis to the University (Cluster). The external expert will assess the quality and quantity of the work done by the student in the final (fourth) presentation. The comments of the examiners during this presentation should be incorporated in the work and report and is to be submitted as hard bound copies before the program exit by the student.

The weights for awarding 150 marks for Project shall be as follows.

A. 3rd Semester - Marks : 50 for Project Progress Evaluation

1. Preliminary Presentation, evaluated by PEC : 15 Marks
2. Progress evaluation by the Project Supervisor/s : 20 Marks
3. End-semester presentation, evaluated by PEC : 15 Marks

B. 4th Semester - Marks : 100 for Final Evaluation

1. Project evaluation by the supervisor/s : 30 Marks
2. Final internal evaluation by PEC : 40 Marks
3. Evaluation of the thesis presentation by an External Expert : 30 Marks