APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Master of Technology

Curriculum, Syllabus and Course Plan

Cluster	**:**	*01*
Branch	**:**	*Interdisciplinary**
Stream	**:**	*Robotics and Automation*
Year	**:**	*2016*
No. of Credits	**:**	*67*

SEMESTER 1

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A	01MA6051	Advanced Mathematics & Optimization techniques	3-0-0	40	60	3	3
B	01EE6701	Robotic System Configuration	3-1-0	40	60	3	4
C	01ME6702	Fluid Power Automation	3-1-0	40	60	3	4
D	01EC6801	Measurements and Sensors for Automation	3-0-0	40	60	3	3
E		Elective 1	3-0-0	40	60	3	3
S	01EC6999	Research Methodology	0-2-0	100			2
T	01ME6891	Seminar I	0-0-2	100			2
U	01EE6793	Automation Lab	0-0-2	100			1
		TOTAL	**15-4-4**	**500**	**300**	**-**	**22**

TOTAL CONTACT HOURS : 23
TOTAL CREDITS : 22

Elective I	
01EE6711	Advanced Control Systems
01EC6811	Soft Computing Techniques
01EC6813	Artificial Intelligence and Expert Systems in Automation
01ME6811	Human Robo Interface

SEMESTER 2

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A	01ME6802	Industrial Automation	4-0-0	40	60	3	4
B	01EC6802	Programmable Logic Control and Computer Numerical Control	3-0-0	40	60	3	3
C	01EE6702	Control, Programming and Calibrations of Robots	3-0-0	40	60	3	3
D		Elective-II	3-0-0	40	60	3	3
E		Elective-III	3-0-0	40	60	3	3
V	01EC6892	Mini Project	0-0-4	100			2
U	01ME6894	Robotics Lab	0-0-2	100			1
		TOTAL	**15-1-6**	**400**	**300**	**-**	**19**

TOTAL CONTACT HOURS : 22
TOTAL CREDITS : 19

Elective II	
01ME6406	System Analysis and Design
01ME6118	Condition Monitoring & Maintenance Engineering
01EE6614	Control of Industrial Drives
01EE6316	Design of Power Electronic System
01EE6432	Sustainable and Translational Engg
01EC6112	Design of Embedded Systems
01EC6114	Digital Image Processing and Computer Vision

Elective III	
01ME6126	Advanced Finite Element Methods
01ME6812	Mechanism and Machine Theory

01ME6128	Robotics
01EE6104	Nonlinear Control Systems
01EE6114	Adaptive Control
01EC6104	Non Linear and Adaptive ControlSystems
01EC6106	Industrial Drives and Control

SEMESTER 3

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A		Elective IV	3-0-0	40	60	3	3
B		Elective V	3-0-0	40	60	3	3
T	01EE7791	Seminar II	0-0-2	100			2
W	01EC7893	Project (Phase 1)	0-0-12	50			6
		TOTAL	**6-0-14**	**230**	**120**	**-**	**14**

TOTAL CONTACT HOURS : 20
TOTAL CREDITS : 14

Elective IV	
01ME7115	Advanced Design Synthesis
01ME7117	Mechatronics System Design
01EE7511	Digital controllers in Power Electronics
01EE7113	Advanced Instrumentation
01EC7115	Robot Dynamics and Control
01EC7117	Computer Aided Design of Control Systems
Elective V	
01ME7811	Product Design and Development
01ME7813	Automotive Mechatronics
01ME7915	Modelling Simulation and Analysis of Manufacturing Systems
01EC7811	Robot Vision

01EC7813	AI for Robotics
01EE7711	Process and Building Automation Systems
01EC7815	Networking Protocols
01EE7713	Micro Electro Mechanical Systems & Techniques
01EC7321	Foundations of Deep Learning

SEMESTER 4

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credit
					Marks	Duration (hours)	
W	01EC7894	Project (Phase 2)	0-0-23	70	30		12
		TOTAL	**0-0-23**	**70**	**30**	**-**	**12**

TOTAL CONTACT HOURS : 23
TOTAL CREDITS : 12

TOTAL NUMBER OF CREDITS: 67

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01MA6051	**Advanced Mathematics and Optimization Techniques**	**3-0-0**	**3**	**2016**

Course Objectives

The objective of this course is to introduce to the master students the basic ideas of linear algebra and optimization techniques and familarise them with the necessary tools from these fields which have got diverse applications in applied sciences and engineering. The course provides a strong background on these areas which, besides being important for their applications, will also be essential for higher studies and research in engineering.

Syllabus

Vector spaces,linear transformation, inner products and orthogonality, Linear programming, simplex methods, integer programming, non-linear optimizations

Expected Outcome

On completion of the course, the students will have acquired knowledge and practical skills in the application of basic ideas of linear algebra such as vector spaces, linear transformations, orthogonality and approximations. They will also have learned the use of optimization techniques applicable to linear, non-linear and integer programming models in various fields of engineering.

References

- Richard Bronson, Gabriel B Costa, *Linear Algebra- An Introduction*, Elsevier, 2/e, 2009.
- David C. Lay, *Linear Algebra*, Pearson Education,4/e, 2012
- Ravindran, Philips, Solberg, *Operations Research: Principles and Practice,* Wiley student Edition, 2007
- Paneerselvam R., *Operations Research*, 2/e, Prentice Hall of India, 2010
- Singiresu S Rao, *Engineering Optimization Theory and Practice*,3/e, New Age International Publishers, 2010.

COURSE PLAN

Module	Course description	Hours	End semester exam % marks
1	Vector spaces and examples, subspaces, linear independence and spanning sets, basis and dimension, co-ordinate representation of vectors	7	15%
2	Linear transformations, matrix representation of linear transformations, properties-kernal and range, change of basis.	**7**	15%
	First Internal Exam		
3	Inner product, length of vectors, orthogonal and orthonormal sets and basis, Gram-Schmidt orthogonolization, orthogonal projections, Least-suqare approximations. Singular value decomposition (All results without proof)	**7**	15%
4	Linear programming problems, formation of LPP, graphical method of solution-Simplex Method, Big M Method, Dual Simplex method	**7**	15%
	Second Internal Exam		
5	Integer linear programming- Gomory's Cutting plane method,Branch and Bound method ,mixed Integer Programming problems, zero-one programming	**7**	20%
6.	Constrained non-linear Optimization-method of Lagrange multiplier, Kuhn Tucher conditions, Quadratic programming	**7**	20%
	End Semester Exam		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6701	Robotic System Configuration	3-1-0	4	2016

Course Objectives

1. To familiarize students with robot classifications and configurations.
2. To acquaint the students with Forward Kinematics and Inverse Kinematics, Trajectory planning, dynamic modeling, control and applications of robots

Syllabus

Robot anatomy; Robot classifications; Robot specifications; Direct kinematics- the arm equation; Inverse Kinematics- solving the arm equation; Velocity analysis and statics of manipulators; Dynamics of manipulators; Workspace analysis and Trajectory planning; Control of manipulators, Robotic Sensors ; Robot applications.

Expected Outcome

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

1. Obtain kinematic model of a robotic manipulator
2. Develop dynamic model of a robotic manipulator
3. Plan a trajectory in joint space and Cartesian space
4. Do the forward and inverse kinematic analysis
5. To design a controller for a robotic manipulator

References

- Robert. J. Schilling , "Fundamentals of robotics – Analysis and control", Prentice Hall of India 1996.
- R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
- Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
- Ashitava Ghosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
- John Iovine- "PIC Robotics: A Beginner's Guide to Robotics Projects Using the PIC Micro", McGraw Hill.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction - Definitions, Robot Elements - links, joints, end effector, actuators, sensors, hydraulic, pneumatic, electric drive systems, Robot specifications, Work envelope of different robots, Classification of Robots. Robot Coordinate Systems- Fundamental and composite rotations, homogeneous co-ordinates and transformations, Kinematic parameters, Direct Kinematics-The D-H representation.	7	15
II	The Arm equation-Kinematic analysis of a typical robot. The inverse kinematics problem – general properties of solutions, Inverse kinematics of a typical 3 DOF Robot. Linear and angular velocities of a rigid body; Manipulator Jacobian; linear and angular velocities of planar 3R manipulator.	7	15
FIRST INTERNAL EXAM			
III	Tool configuration vector, Workspace analysis, trajectory planning-steps in trajectory planning, joint space techniques, Cartesian space techniques, The pick and place operation –Continuous path motion, Tool configuration Jacobian matrix.	10	15
IV	Manipulator Dynamics - Dynamic model of a robot using Lagrange's Equation, 1DOF and 2 DOF manipulator dynamic modelling, State space model of 1 DOF and 2DOF manipulators. Steps for building servomotor controlled robot arm.	12	15
SECOND INTERNAL EXAM			
V	Feedback control of a single link manipulator- PID control and digital control of a single link manipulator; Nonlinear Control - PD gravity control, Computed torque control, Variable Structure control, Impedance control.	10	20
VI	Sensors in Robotics- status sensors, environment sensors, quality control sensors, safety sensors etc. Robot vision - Image representation, Perspective and inverse perspective Transformations. Robot Applications- Industrial Applications- Material handling, Processing, Assembly, Inspection etc.	10	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6702	**Fluid Power Automation**	**3-1-0**	**4**	**2016**

Course Objectives

The objective of this course is to reinforce basic ideas of fluid power automation. The basic building blocks of pneumatic and hydraulic automation systems will be dealt with in detail and enable the students to design and optimise pneumatic and hydraulic automation schemes.

Syllabus

Classification of drives, Drive characteristics, Direction, flow and pressure control valves, Electro hydraulic servo valves, Typical Design methods – sequencing circuits design, Electrical control of pneumatic and hydraulic circuits, Proportional control of hydraulic systems.

Expected Outcome

On completion of the course, the students will have acquired knowledge and practical skills in the modelling and optimisation of hydraulic and pneumatic systems which has applications in diverse areas of process and manufacturing automation.

References

1. Peter Rohner, Fluid Power Logic Circuit Design, Mcmelan Prem, 1994.
2. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988
3. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978
4. Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London, 1979
5. Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967
6. Dudbey. A. Peace, Basic Fluid Power, Prentice Hall Inc, 1967.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Classification of drives-hydraulic, pneumatic and electric –comparison ISO symbols for their elements, Selection Criteria	**5**	**15**
	Generating Elements- Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification	**5**	
II	Drive characteristics – Utilizing Elements-- Linear actuator – Types, mounting details, cushioning – power packs –accumulators	**8**	**15**
FIRST INTERNAL EXAM			
III	Control and regulation Elements – Direction, flow and pressure control valves--Methods of actuation, types, sizing of ports. spool valves-operating characteristics	**8**	**15**
IV	Electro hydraulic servo valves-Different types-characteristics and performance	**8**	**15**
SECOND INTERNAL EXAM			
V	Typical Design methods – sequencing circuits design - combinational logic circuit design- cascade method-Karnaugh map method.	**12**	**20**
VI	Electrical control of pneumatic and hydraulic circuits- use of relays, timers, counters, interfacing with PLCs, Proportional control of hydraulic systems	**9**	**20**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC6801	**MEASUREMENTS AND SENSORS FOR AUTOMATION**	**3-0-0**	**3**	**2016**

Course Objectives

The objective of this course is to provide the basic understanding about operational characteristics and applications of various sensors, transducers, measurements and instrumentation.

Syllabus

Introduction to Measurement, Testing & Calibration, Introduction to Sensors, Displacement Measurement, Pressure Measurement, Temperature Measurement, Flow Measurement,Level Measurement, Magnetic sensors, Radiation sensors, Feedback transducer system, Advancement in Sensor technology, MEMS, Nano Sensors, Sensor Signal Conditioning

Expected Outcome

On completion of the course, the students will have acquired knowledge and skills in using sensors with conditioning circuits for automation systems which has applications in diverse areas of process and manufacturing automation.

References

K.L. Kishore,"Electronic Measurement and Instrumentation "Pearson .

D. Patranabis, "Sensors and Transducers", PHI Learning Pvt. Ltd., 2nd edition

A.K.Ghosh,"Introduction to Measurements and Instrumentation "4th Edition, PHI.

D V S Murty, "Transducers and Instrumentation", PHI Learning Pvt. Ltd.

B. C. Nakra., K. K. Chaudhry, "Instrumentation, Measurement and Analysis", 4th Edition, TMH.

W. D. Cooper, "Modern Electronics Instrumentation & Measurement Techniques", PHI.

John .P.Bentley, "Principles of Measurement Systems", Pearson

E.O.Doebelin,Dhanesh N Manik, "Measurement Systems",6th Edition,Mcgraw Hill Edu.

Bolton W., "Mechatronics - Electronic Control Systems in Mechanical & Electrical Engineering", (2e), Longman Publishers, 2002.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to Measurement:Significance of measurement, Different methods of measurement, Classification of measuring instruments,Application of measurement systems, typical measurement schemes. Units and Standards:MKS, SI units of engineering parameters, Details of different standards-mass, length, time, frequency, temperature, EMF, ampere, sub standards and lab standards .	**3**	**15**
	Performance Characteristics: Definition of range, span, accuracy, precision, drift, sensitivity, reproducibility, repeatability, dead zone, resolution, hysteresis, threshold, zero error, noise, linearity, loading effect, static characteristics.	**3**	
II	Dynamic Characteristics: Dynamic response; Transient response; speed of response, fidelity, measuring lag etc, Linear approximation, Introduction to compensation techniques. Significance of testing and calibration, Calibration curve, Standards for calibration, Different calibration procedures-primary, secondary, direct, indirect, routine calibration, Calibration setup:pressure gauge, level etc.	**6**	**15**
FIRST INTERNAL EXAM			
III	Introduction to Sensors: Definition and differences of sensors and transducers, Classification, static and dynamic		

	characteristics, electrical characterization, mechanical and thermal characterization including bath-tub curve. Sensors and Transducers: Transducer classification, Active and Passive Transducers, Potentiometric Transducers, Linear and non-linear potentiometer, Resistance/Bonded Type Strain Gauge. Displacement Measurement:Linear/Angular displacement, Pneumatic/Electric/Optical/ Ultrasonic/Electronic Displacement Transducers, Tactile and Proximity Sensors, Typical application schemes.	**6**	**15**
IV	Pressure Measurement:Pressure Units, Force Summing Devices, Secondary Transducers, Vaccum Measurement, Torque Measurement, Tachogenerators. Temperature Measurement:Electric Method, Change in Electrical Properties, RTD, Thermocouples, Thermistors, Thermowells. nuclear thermometers, resistance change type thermometric sensors. Flow Measurement:Reynold Number, Head type flowmeters, Velocity measurement type flowmeters, Mass flow measurement type flow meters.	**6**	**15**
SECOND INTERNAL EXAM			
V	Level Measurements: Importance, advantage and limitation of different instruments, visual level indicators, float type, Purge method of measuring level, Buoyancy method, Resistance and capcitance probes for level measurement, limit switches, level measurement in pressurized vessels, solid level measurement techniques	**6**	**20**

	Magnetic sensors: Basic working principles, Magnetostrictive, Hall effect, Eddy current type. Radiation sensors: Photo-detectors, Photo-emissive, photomultiplier, scintillation detectors. Electroanalytical sensors: Electrochemical cell, SHE, Polarization, Reference electrode, Metal electrodes, Membrane electrodes, Electroceramics		
VI	Feedback transducer system: Inverse transducer, Self-balancing transducer, Servo-operated manometer, Feedback pneumatic load cell, integrating servo. Advancement in Sensor technology: Introduction to smart sensors, Film sensors, Introduction to semiconductor IC technology and Micro Electro Mechanical System(MEMS), Nano-sensors. Bio-Sensors. Sensor Signal Conditioning: Amplification/Attenuation using Op-Amp, Filtering, Protection from high current/Voltage, Wheatstone bridge, ac bridge, Comparator, Analog to digital conversion, Digital to Analog Conversion	**6**	**20**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6711	Advanced Control Systems	3-0-0	3	2016

Course Objectives

1. Acquaint the students with classical and modern control theory
2. Familiarise the students with some real systems, which use automatic control
3. Introduce to students with mathematical modeling of physical systems
4. Introduce students to design of feedback control systems using classical and modern control theory.

Syllabus

Open loop and closed loop systems, Modelling of dynamic systems using transfer function, time domain and frequency domain analysis of dynamic systems, state space analysis, simple controllers for robotic manipulators.

Expected Outcome

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

1. Obtain transfer function or state space model of dynamic systems
2. Analyse a system using classical or modern control theory
3. Design simple controllers for a dynamic system

References

1. Ogata K., Modern Control Engineering, Prentice Hall of India, New Delhi, 2010.
2. Nagarath I. J. and Gopal M., Control System Engineering, Wiley Eastern, 2008.
3. Dorf R. C. and R. H. Bishop, Modern Control Systems, Pearson Education, 2011
4. Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern, 2010.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Review of system concepts, linear, non - linear, static, dynamic, time variant and time invariant, continuous time and discrete time, distributed and lumped parameter systems. Open loop and closed loop systems. Transfer function -T.F of simple - Mechanical and Electromechanical systems; block diagram representation – block diagram reduction - signal flow graph - Mason's gain formula - characteristics equation.	7	15
II	Time domain analysis of control systems: Transient and steady state responses -test signals - time domain specifications - first and second order systems - impulse and step responses - steady state error analysis – static error coefficient of type 0,1,2 systems - Dynamic error coefficients – Design and implementation of PID controllers	7	15
FIRST INTERNAL EXAM			
III	Concept of stability: stability of feedback system - Routh's stability criterion - Root locus based analysis - Frequency domain analysis: Introduction - Bode plot- Frequency domain specifications: stability analysis using bode plot.	10	15
IV	State space analysis of systems: Introduction to state concept - state equation of linear continuous time systems, matrix representation of state equations. Phase variable and canonical forms of state representation	12	15
SECOND INTERNAL EXAM			
V	Solution of time invariant autonomous systems- state transition matrix- relationship between state equations and transfer function. Properties of state transition matrix- controllability & observability. State feed back design via pole placement technique.	10	20
VI	PID control of single link manipulator, digital control of single link manipulator, PID control of multilink manipulator, model based control, force control of a single mass, partitioning a task for force and position control, stability analysis of single link manipulator.	10	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC6999	**Research Methodology**	**0-2-0**	**2**	**2016**

Course Objectives

1. Gain motivation to pursue research projects.
2. Understand basic structure of the research process.
3. Acquire the skills necessary to undertake a research project in an ethically correct way.
4. Present and publish the outcomes of research in a well structured manner.

Syllabus

Introduction to research –significance, characteristics, types.
Motivation for research
Thinking – levels and styles, creativity.
Problem finding- analytical and logical reasoning, creative problem solving.
Literature survey- types of literature, terminologies.
Experiment and modeling -data representation and analysis.
Oral and written communication.
Publishing and patenting , Professional Ethics

Expected Outcome

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

1. Approach PG research projects with enthusiasm and confidence.
2. Identify appropriate research topics in coordination with the supervisor.
3. Deliver well structured technical presentations in seminars and conferences.
4. Write M. Tech thesis and other technical reports in proper manner.

References

NPTEL Video :

1. S. Karmalkar, Introduction to Research – Video course.

Books :

1. E. M. Phillips and D. S. Pugh, "How to get a PhD - a handbook for PhD students and their supervisors", Viva books Pvt Ltd.
2. G. L. Squires, "Practical physics", Cambridge University Press
3. Handbook of Science Communication, compiled by Antony Wilson, Jane Gregory, Steve Miller, Shirley Earl, Overseas Press India Pvt Ltd, New Delhi, 1st edition 2005
4. C. R. Kothari, Research Methodology, New Age International, 2004
5. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.

6. Leedy P. D., Practical Research: Planning and Design, McMillan Publishing Co.
7. Day R. A., How to Write and Publish a Scientific Paper, Cambridge University Press, 1989.
8. Peter Medawar, 'Advice to Young Scientist', Alfred P.Sloan Foundation Series, 1979.
9. E. O. Wilson, Letters to a Young Scientist, Liveright, 2014.
10. R. Hamming, You and Your Research, 1986 Talk at Bell Labs.

References Books:

1. Y. A. Cengel and M. A.Boles,Thermodynamics An Engineering Approach,McGraw Hill, 2011
2. G.VanWylen, R.Sonntag and C.Borgnakke, Fundamentals of Classical Thermodynamics, John Wiley & Sons,2012
3. Holman J.P., Thermodynamics, McGraw Hill, 2004

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	**Introduction**: Meaning and significance of research; skills, habits and attitudes for research; Types of research, Characteristics of good research. Status of research in India. Motivation for research: Motivational talks on research 1. "You and Your Research"- Richard Hamming 2. "Advise to young scientists"-TED Talks, E O Wilson Discussion based on the above talks	4	10
II	**Thinking skills:** Levels and styles of thinking; common-sense and scientific thinking; examples, Problem solving strategies – reformulation or rephrasing, techniques of representation, logical thinking, division into sub-problems, verbalization, awareness of scale; Importance of graphical representation; examples. **Creativity:**Some definitions, illustrations from day to day life; intelligence versus creativity; gift or skill; creative process; requirements for creativity – role of motivation and open vs. closed minds	5	20
	FIRST INTERNAL EXAM		
III	**Problem finding and literature survey**:Attributes and sources of research problems; problem formulation, multiple approaches to a problem, analytical and analogical reasoning, examples; Creative problem solving using Triz, Prescriptions for developing creativity and problem solving. Information gathering – reading, searching and documentation; types of literature. Journal index and impact factor.	4	20
IV	Scientific method; role of hypothesis in experiment; units and dimensions; dependent and independent variables; control in experiment; precision and accuracy; need for precision; definition, detection, estimation and reduction of random errors; statistical treatment of data; definition, detection and elimination of systematic errors; design of experiments; experimental logic; documentation Types of models; stages in modeling; curve fitting; the role of approximations; problem representation; logical reasoning; mathematical skills; continuum/meso/micro scale approaches for numerical simulation; Two case studies illustrating experimental and modeling skills.	5	20
	SECOND INTERNAL EXAM		

V	**Effective communication - oral and written** Examples illustrating the importance of effective communication; stages and dimensions of a communication process. Oral communication –verbal and non-verbal, casual, formal and informal communication; interactive communication; listening; form, content and delivery; various contexts for speaking- conference, seminar etc; visual aids Written communication - form, content and language; layout, typography and illustrations; nomenclature, reference and citation styles, contexts for writing – paper, thesis, reports etc. Tools for document preparation-LaTeX. Prescriptions for developing communication skills.	5	20
VI	**Professional ethics:** Professional integrity, objectivity, fairness and consistency; loyalty; plagiarism and research ethics; safety.	4	10
END SEMESTER EXAM			

Assignment-1 (Marks allotted: 10%)

Present the motivational talks given in module-I and conduct a group discussion. The topic for discussion shall be based on the good practices in research as conversed in these talks.

Assignment-2(Marks allotted: 25%)

Conduct literature survey on a suitable research topic. Read atleast five papers already reported and prepare a report based on this.

Assignment-3(Marks allotted: 25%)

Conduct an oral presentation based on the above report with the help of visual aids. Present the details of experiments/analysis and explain the reported results. Answer the questions raised.

End semester exam (Marks allotted: 40%)

This is based on the full syllabus and weightage for different modules is as per the above table.
The question paper can be divided into two sections A &B. The questions in section A shall be of multiple choice type. The weightage for this section is 75 %. For Section-B, questions are intended to test the written communication ability of students.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6591	Seminar I	0-0-2	2	2015

Course Objectives

To make students

1. Identify the current topics in the specific stream.
2. Collect the recent publications related to the identified topics.
3. Do a detailed study of a selected topic based on current journals, published papers and books.
4. Present a seminar on the selected topic on which a detailed study has been done.
5. Improve the writing and presentation skills

Approach

Students shall make a presentation for 20-25 minutes based on the detailed study of the topic and submit a report based on the study.

Expected Outcome

Upon successful completion of the seminar, the student should be able to

1. Get good exposure in the current topics in the specific stream.
2. Improve the writing and presentation skills.
3. Explore domains of interest so as to pursue the course project.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6793	**Automation Lab**	**0-0-2**	1	2016

Course Prerequisites

Basic knowledge of electrical circuits and components like relays, timers , proximity sensors, etc.

Course Objectives

This laboratory aims to introduce the various elements of automation namely actuators and sensors. It also enable the students to plan, design and optimise logic circuits using these basic elements.

Expected Outcome

After completing the laboratory, the students will be able to design and build automation logic circuits using the basic elements

List of Experiments

Excercises on Hydraulic circuits.
Usage of DCVs in hydraulic logic.
Experiments on electro-hydraulics.
Excercises on pneumatic circuits.
Cylinder sequencing using pneumatic circuits.
Experiments on Electro pneumatics.
Simulation of Pneumatic and Hydraulic Circuits using Automation Studio Software.
Experiments using Sensors.
Calibration of Proximity sensors.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6702	INDUSTRIAL AUTOMATION	3-1-0	4	2016

Course Objectives

To identify the managerial concepts behind industrial automation and to justify the need of industrial automation.

To identify the different hard ware components required for automation.

To identify the information technology components in automation.

Syllabus

Automation methodologies: Concepts – Types of Automation Trends in manufacturing –Flexible manufacturing systems –computer integrated manufacturing – Automated assembly systems.

CNC systems: CNC Mechanical systems **Material Handling Systems**.

Group Technology and cellular manufacturing CAPP

Inspection automation: Inspection automation, CMMs, online inspection systems,

Communication systems for Automation – Computer networks and protocols.

DFMA.

Expected Outcome

References

1. YoramKoren, "ComputerControlofManufacturingSystems",TataMcGraw-HillEdition2005.
2. Automation, Production Systems and Computer Integrated Manufacturing- M.P.Groover, Pearson Education.5th edition, 2009.
3. W.Bolton, "Mechatronics:A MultidisciplinaryApproach,4/E",Pearson EducationIndia.
4. RadhakrishnanP, "CNCMachines",NewCentralBookAgency,1992.
5. "Mechatronics",HMT,TataMcGraw-Hill,1998.
6. Computer Based Industrial Control- Krishna Kant, EEE-PHI,2nd edition,2010
7. Product Design for Manufacture and Assembly, Third Edition (Manufacturing Engineering and Materials Processing) -Geoffrey Boothroyd, Peter Dewhurst , Winston A. Knight-CRC Press.
8. Chapman andHall, "StandardHandbook of IndustrialAutomation",Onsidine DM C &OnsidineGDC",NJ, 1986

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	**Introduction:** Automation in Production System, Principles and Strategies of Automation, BasicElements of an Automated System, Levels of Automations. Flow lines & Transfer Mechanisms, Fundamentals of Transfer Lines	**7**	**15**
II	Numerical control-concepts-evolution - CNC-Structure of CNC machines, components, ball screws and guideways. Spindle, bearings and mountings. Drive systems. Automated tool changers and pallet changers. Accessories	**8**	**15**
FIRST INTERNAL EXAM			
III	**Material handling and Identification Technologies:** Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods.	**7**	**15**
IV	**Automated Manufacturing Systems:** Components, Classification and Overview of Manufacturing Systems, Manufacturing Cells, GT and Cellular Manufacturing, FMS, CIM .**Quality Control Systems:** Traditional and Modern Quality Control Methods, Inspection Principles and Practices, Inspection Technologies.	**7**	**15**
SECOND INTERNAL EXAM			
V	**Control Technologies in Automation:** Industrial Control Systems, Process Industries Versus Discrete-Manufacturing Industries, Continuous Versus Discrete Control. Introduction & Automatic Process Control, **Building Blocks of Automation Systems**: LAN, Analog & Digital I/O Modules, SCADASystems & RTU. **Distributed Control System:** Functional Requirements, Configurations	**8**	**20**
VI	Design for Manufacture, Assembly and Automation. Design considerations for automaton. Poka Yoke principles for automation	**7**	**20**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC6802	**Programmable Logic Control and Computer Numerical Control**	3-0-0	3	2016

Course Objectives

The objective of this course is to provide a thorough understanding about Programmablw Logic Control and Computer Numerical Control.

Syllabus

Introduction to Logic Circuits, Programmable Logic Controller Architecture, PLC programming methods, Ladder Programming, Programming Style, Communication links for PLC, Fundamentals of Numerical Control, Classification, Features of NC machine tools, Interpolation, Control loops for CNC, Manual part programming, Computer aided programming, APT programming, Direct Numerical Control, Distributive numerical control.

Expected Outcome

On completion of the course, the students will have acquired knowledge and skills in using PLCs, Ladder programming, CNC machines, Manual part programming and Computer Aided Programming.

References

1. Programmable Logic Devices and Logic Controllers, Enrique Mandado, Jorge Marcos, Serafin
A. Peres, Prentice Hall, 1996.
2. Introduction to Programmable Logic Controllers, Gray Dunning, Delamar Thomson Learning,
1998.
3. Programmable Controllers – An Engineers's Guide, 2nd Edition, E.A. Parr, Newnes, 1999.
4. Programmable controllers, Hardware, Software & Applications, George L. Batten Jr., Mc GrawHill, 2nd Edition, 1994.
5. Koren Y., *Computer Control of Manufacturing Systems,* McGraw Hill, 1983.
6. Devdas Shetty & Richard A Kolk - Mechatronics System Design – PWS Publishing Company
7. Mechatronics – HMT Ltd., TMH
8. Bolton-Mechatronics- Pearson-Fourth edn.

COURSE PLAN

Module	Contents	**Hours Allotted**	**% of Marks in End-Semester** Examination
I	Introduction to logic circuits, Logic Controllers – Combinational and Sequential Logic Controllers - Synchronous and asynchronous logic controllers – Design examples- Non modular, Modular and	6	15

	Semi-modular logic controllers.		
II	Programmable Logic Controllers – Basic PLC with Load and Store operations, PLC with Conditional Instructions – Input and Output modules – Discrete AC/DC and Analog Input/Output – Modular PLC - Relays for Logic Control – Relay Diagrams - PLC programming Methods – IEC 1133-3 standard – Ladder programming	6	15
FIRST INTERNAL EXAM			
III	Program and Data organisation in PLC – Basic relay instructions – Timers and Counters – Comparison and data handling – Sequencer instructions. Programming Style – Top Down design – Proprietary and Standard communication links for PLC – PROFIBUS.	6	15
IV	Fundamentals of numerical control - advantages of NC systems - classification of NC systems - point to point and contouring systems - NC and CNC - incremental and absolute systems open loop and closed loop systems - features of NC machine tools - fundamentals of machining. Introduction to Modern CNC Machines - Advantages of CNC Machines.	6	15
SECOND INTERNAL EXAM			
V	Interpolation – linear interpolator - circular interpolators Complete interpolator - Control Loops for CNC – CNC software interpolator. Manual part programming examples - point to point programming and simple contour programming, canned cycles.	6	20
VI	Computer aided programming - concepts - APT programming – part programming examples Geometric definitions- cutter motion definitions- postprocessor statements-generation and execution of APT programs. Direct Numerical Control (DNC), Distributive Numerical control, DNC software.	6	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6702	**Control, Programming and Calibration of Robots**	**3-0-0**	**3**	**2016**

Course Objectives

1. To familiarize students with different control schemes for robots
2. To acquaint the students with programming of robots
3. To familiarize students with calibration of robots

Syllabus

Control of Robots in task space, Passivity based control, Compliant motion control, Hybrid position and force control, Control of mobile robots and quadcopters to track different trajectories, Vision based Control- Position based visual servoing, Image based visual servoing, Hybrid visual servoing. Programming of robots using BASIC, VAL, RAPID, ROS. Fundamental algorithms in MATLAB for modelling and control of robots. Robot calibration methods.

Expected Outcome

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

1. Design controllers for robotic manipulator in task space
2. Develop hybrid position and force controllers
3. Develop vision based controllers
4. Program robots using BASIC, VAL, RAPID & ROS
5. Implement trajectory tracking controllers for mobile robots and quadcopters
6. Path planning and localization of UGVs
7. Calibrate robotic manipulators for a particular application

References

1. Bruno Siciliano, Lorenzo Sciavicco, and Luigi Villani, "Robotics: Modelling, Planning and Control", Springer Publishing Company, 2008.
2. S R Deb, "Robotics Technology and Flexible Automation", Tata McGrawHill, NewDelhi, 2005.
3. Wisama Khalil, Etienne Dombre, "Modeling, Identification and Control of Robots", Taylor & Francis, 2002.
4. Peter Corke, "Robotics, Vision and Control-Fundamental Algorithms in MATLAB", Springer Tracts in Advanced Robotics, volume 73.
5. Z S Roth, B W Mooring B Ravani, "An overview of Robot Calibration", IEEE journal of Robotics and Automation, October 1987.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Control of robotic manipulators in task space- PID Control and Computed torque control, Passivity based position control and tracking control, compliant motion control, Hybrid position and force control, Resolved rate motion control. Selection of motors for robotic manipulators & AGVs, Control of different electric drives - DC Motor, servo motor, stepper motor, BLDC motor. Implementation of PID controller.	7	15
II	Kinematic model of steered robot and differentially driven mobile robot , Control of a mobile robot to move to a point, to follow a line, following a path, moving to a pose, Dynamic model of quadcopter-Controller design to track any desired trajectory.	6	15
FIRST INTERNAL EXAM			
III	Vision based Control- configuration of a vision system, image segmentation, image interpretation, Pose estimation, Stereo vision, Camera Calibration, Position based visual servoing, Image based visual servoing, Hybrid visual servoing.	7	15
IV	Robot Programming-classification of robot languages, teach in and Offline programming, programming using BASIC, programming using VAL- representing robot locations, trajectory control, monitor commands. RAPID language basic commands- Motion Instructions-Pick and place operation using Industrial robot- manual mode, automatic mode. RobotStudio- Create a mechanism, autopath control, collision control, reachability, editing and debugging, Introduction to ROS and simple programming examples.	8	15
SECOND INTERNAL EXAM			
V	Fundamental algorithms in MATLAB- for trajectory generation-one dimensional and multidimensional case, trajectory tracking, Navigation-reactive navigation, Map based planning, Localization-Dead reckoning, Monte-Carlo Localization, Kinematic & Dynamic modeling, Control of robots.	7	20
VI	Robot Calibration methods- level 1, 2, 3 calibration with model, measurement, identification and correction, Manual Calibration, Bulls eye – calibration of Tool Centre Point, Calibration by Force Control, Laser based Calibration, Absolute accuracy, PosEye, Calibration of work object co-ordinate system.	7	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6432	**Sustainable and Translational Engineering**			

Course Objectives

The purpose of this course is:-

1. To bring in to focus the basics aspects of sustainable development.

2. To have a general understanding on global environmental issues and the different aspects involved in Green Technology.

Expected Outcome

The student will be able to

1. Understand the concept of sustainable development

2. To have an insight in to global environmental issues

3. Understand the different aspects of green Technology

Syllabus

History and emergence of the concept of Sustainable Development; Economic dimensions, Environmental dimension; Framework for sustainability, assessment of sustainable performance;

Industrialization, Globalization and Environment; Global environmental issues; Waste land reclamation, Resource degradation, carbon credits and Carbon trading – Carbon footprint;

Energy: Conventional and renewable sources, Green buildings, green materials, Technology and sustainable development, Sustainable urbanization, Industrial Ecology.

References

1. Kurian Joseph & R. Nagendran' Essential Environmental studies'. Pearson education, New Delhi, 2004.

2. S.C Bhatia, Environmental Pollution and Control in Chemical Process Industries, Khanna Publishers, Delhi, 2005.

3. Kirkby, J.O' Keefe, P. and Timberlake, Sustainable Development, Earthscan Publication,

London, 1996.

4. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.

5. S.S Purohit ,Green Technology-An approach for sustainable environment, Agrobios publication, India, 2008.

6. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS)

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	History and emergence of the concept of Sustainable Development – Framework of Sustainability, economic dimensionsenvironmental dimension		
II	Framework for achieving sustainability, assessment of sustainable performanceIndustrialization – Globalization and Environment		
	FIRST INTERNAL EXAM		
III	Global environmental issues: - desertification –– green house gases- greenhouse effect, ozone layer depletion- global warming – acid rain – deforestation..		
IV	Waste land reclamation-Resource degradation, carbon credits and Carbon trading-International summits- conventions-agreements- trans boundary issues- Carbon footprint		
	SECOND INTERNAL EXAM		
V	Energy sources: Basic concepts-Conventional and non-conventional, solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans, Geothermal energy.		
VI	Green buildings, Sustainable cities, Sustainable Urbanisation Sustainable transport, Green Engineering, Industrial Ecology, Industrial symbiosis.		
	END SEMESTER EXAM		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC6112	**Design of Embedded Systems**			

Course Objectives

1. To explore the concepts of embedded system design
2. To Study about embedded system design and its analysis
3. To Study about software development tools

Syllabus

Characteristics of embedded computing applications, design process, Embedded Computing Platform CPU bus-memory devices-I/O device, Program Design and Analysis, basic compilation techniques, design methodologies, Introduction to assembler, compiler, cross-compiler, linker and integrated development environment debugging strategies-simulators-emulators-logic analyzers

Expected outcome

1. Understand the concepts of embedded system design
2. Understand software development tools
3. Understand , Analyze embedded system design and its applications

References

1. Wayne Wolf, "Computers as Components-Principles of Embedded Computing System Design", Morgan Kaufman Publishers, 2008.

2. David E. Simon, "An Embedded Software Primer", Pearson Education, 2004.

3. Frank Vahid and Tony Givargi,"Embedded System Design: A Unified Hardware/Software Introduction", John Wiley & Sons, 2001.

4. Steve Heath, "Embedded System Design", Elsevier science, 2003.

5. Arnold S. Berger, "Embedded System Design: An Introduction to Processors"

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction-characteristics of embedded computing applications-challenges in embedded computing design –design process: requirements-specification-architecture design-designing hardware and software components-system integration and testing-structural description behavioral description.		
II	The Embedded Computing Platform CPU bus-memory devices-I/O devices-component interfacing-development and debugging-testing-design examples – alarm clock.		
FIRST INTERNAL EXAM			
III	Program Design and Analysis Introduction-design patterns-data flow graph-control /data flow graphs-assembly and linking.		
IV	Basic compilation techniques-analysis and optimization of execution time, energy, power and program size program validation and testing-design examples :software modem		
SECOND INTERNAL EXAM			
V	System Design Techniques Introduction-design methodologies-requirement analysis - specifications- system analysis and architecture design-quality assurance		
VI	Software Development and Tools, Introduction to assembler, compiler, cross-compiler, linker and integrated development environment debugging strategies-simulators-emulators-logic analysers - : introduction to JTAG		
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6118	**Condition Monitoring & Maintenance Engineering**			

Course Objectives

1.To introduce Various predictive maintenance techniques

2. To familiarize the Destructive and Nondestructive testing techniques

3. Analysis and remedial of condition monitoring and maintenance of various machinery in plants.

Syllabus

Introduction to Machine Condition Monitoring and Condition Based Maintenance, Fundamentals of Machinery Vibration and Rotor dynamics, Vibration & Noise Monitoring, Digital Signal Processing & Instrumentation, Condition monitoring Techniques, Machine Tool Condition Monitoring

Expected outcome

1. Students must be able to apply predictive maintenance techniques.
2. Students must be able to handle the maintenance of industrial machinery in plants.

References

Text Books:

1. Machinery Condition Monitoring, Principles & Practices, Amiya R. Mohanty, CRC Press, 2015.

2. Vibration Based Condition Monitoring, Robert Bond Randall, John Wiley Publication-2010

References :

1. Mechanical Fault diagnosis and condition monitoring- R.A.Collacott

2. First Course on Condition monitoring in the process Industry, Manchester, Edited by M.J Neale.

3. Condition Monitoring Manual- National Productivity Council, New Delhi

4. Condition Monitoring Using Computational Intelligence Method, Tshilidzi Marwala, Springer Publications, ISBN-978-4471-2379-8, 2012

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to condition monitoring and fault diagnosis –Machinery failure Type and cause – Frequency of failure- Bath-tub curve- Basic Maintenance strategies		
II	Characteristics of Vibrating systems- Vibration of continuous systemsMode shape and operational deflection shapes- Experimental modal analysis-Simple rotor disc systems and critical 15 speed-Condition monitoring of large rotor systems		
	FIRST INTERNAL EXAM		
III	Vibration monitoring- Misalignment and eccentricity detection-Bearing fault- Gear fault-Cavitations induced vibration in fluid machines – Nois e measurement : Decibel scale – relationship between pressure, intensity and power – Noise source		
IV	Introduction- Classification of signals-Frequency domain- Signal Analysis-Fourier series-Discrete Fourier Transforms – Fundamentals of FFT,. Auto power spectrum – Frequency Response Spectrum – Basic Measuring Equipments for Vibration, Force, Rotational speed		
V	Introduction- Radiography- Ultrasound Testing- Thermography-		

	Wear Debris Analysis- Eddy current Testing – Acoustic Emission-		
VI	Introduction- Case studies of condition monitoring in Process & Manufacturing industry. Bend Pulley Failure Analysis, Vibration measurement on a multi 20 - stage gearbox drive set.		
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6128	Robotics			

Course Objectives

1. To introduce the basic concepts, parts of robots and types of robots.
2. To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
3. To discuss about the various applications of robots, justification and implementation of robot

Syllabus

Introduction and classification of robots

Robot kinematics and dynamics

Robot drives and power transmission systems

Robot end effectors Path planning & programming

Robot Language- Software- Industrial application

Expected outcome

The Student must be able to design automatic manufacturing cells with robotic control using

The student could understand the principle behind robotic drive system, end effectors, sensor, machine vision robot kinematics and programming.

References

1 Deb S. R. and Deb S., "Robotics Technology and Flexible Automation", Tata McGraw Hill Education Pvt. Ltd, 2010.

2. John J.Craig , "Introduction to Robotics", Pearson, 2009.

3. Mikell P. Groover et. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, New York, 2008.

4. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.

5. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics : Control, Sensing, Vision and Intelligence", McGraw Hill, 1987

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Specifications of Robots- Classifications of robots – Work envelope Flexible automation versus Robotic technology – Applications of Robots		
II	ROBOT KINEMATICS AND DYNAMICS :Positions, Orientations and frames, Mappings: Changing descriptions from frame to frame, Operators: Translations, Rotations and Transformations Transformation Arithmetic - D-H Representation - Forward and inverse Kinematics Of Six Degree of Freedom Robot Arm – Robot Arm dynamics		
FIRST INTERNAL EXAM			
III	ROBOT DRIVES AND POWER TRANSMISSION SYSTEMS: Robot drive Mechanisms, hydraulic – electric – servomotor- stepper motor Pneumatic drives, Mechanical transmission method - Gear transmission,Belt drives, cables, Roller chains, Link - Rod systems Rotary-to-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws		
IV	ROBOT END EFFECTORS : Classification of End effectors – Tools as end effectors. Drive system for grippers-Mechanicaladhesive-vacuum-magneticgrippers. Hooks&scoops. Gripper force analysis and gripper design. Active and passive grippers.		
SECOND INTERBNAL EXAM			
V	Drive system for grippers-Mechanical adhesive-vacuum-magneticgrippers. Hooks &scoops.Gripper force analysis and gripper design. Active and passive grippers.		
VI	Robot languages -.computer control and Robot software 4 20 Industrial Application of robots		
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6114	**Adaptive Control**			

Course Objectives

1. Inculcate conceptual understanding of adaptive control

2. Provide knowledge on various adaptive schemes, with a basic understanding on closed loop system stability and implementation issues

3. Develop ability to design suitable stable adaptive scheme to meet the performance objectives even in the presence of disturbances and changing operating conditions

4. Design model reference adaptive control system considering matched structured uncertainties

5. Identify the need and apply appropriate adaptive control design technique to real-time systems

Syllabus

Adaptive Control, Adaptive Schemes, Adaptive Control Problem; Applications, Regression Models, Recursive Least Squares, Real-Time Parameter Estimation, Direct and Indirect Self-Tuning Regulators Pole Placement Design, MDPP, Model Reference Adaptive Systems, MIT Rule, Design of MRAS Using Lyapunov Theory, Relations between MRAS and STR, Adaptive Feedback Linearization, Adaptive Back Stepping, Gain Scheduling, Design of Gain-Scheduling Controllers, Nonlinear Transformations. Practical Issues and Implementation, Operational Issues, Case Study

Expected outcome

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

1. Formulate adaptive control design problem

2. Identify suitable adaptive controller for a given system with uncertain parameters

3. Apply adaptive design techniques to real-time systems whose parameters change during operation.

4. Implement adaptive control schemes to meet the performance objectives in challenging situations.

References

1. Karl Johan Astrom and BjomWittenmark, 'Adaptive Control' , Addison Wesley,2003

2. Shankar Sastry, 'Adaptive Control', PHI (Eastern Economy Edition), 1989

3. Karl Johan Astrom, 'Adaptive Control', Pearson Education, 2001

4. Petros A Loannou, Jing, 'Robust Adaptive Control', Prentice-Hall, 1995

5. Eykhoff P, 'System Identification: Parameter and State Estimation', 1974

6. Ljung, 'System Identification Theory for the User', Prentice-Hall, 1987

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction: Adaptive Control, effects of process variation - Adaptive Schemes - Adaptive Control problem - Applications - RealTime Parameter Estimation: Introduction - Regression Models - Recursive Least Squares - Exponential Forgetting - Estimating Parameters in Dynamical Systems - Experimental Conditions – Loss of identifiability due to feedback		
II	Deterministic Self-Tuning Regulators: Introduction - Pole Placement Design, MDPP - Design of Indirect Self-tuning Regulators - Continuous Time Self-tuners - Direct Self-tuning Regulators - Properties of Direct Self-tuners - Disturbances with Known Characteristics, Case Study		
FIRST INTERNAL EXAM			
III	Model Reference Adaptive Systems: Introduction - MIT Rule - Significance of Adaptation Gain - Lyapunov Stability Theory - Design of MRAS Using Lyapunov Theory - Adaptation of a Feedforward Gain - Applications to Adaptive Control, Case Study		
IV	Relations between MRAS and STR - Nonlinear Systems - Feedback Linearization - Adaptive Feedback Linearization - Back Stepping - Adaptive Back Stepping, Case Study		
SECOND INTERBNAL EXAM			
V	Gain Scheduling: Introduction - Principle - Design of GainScheduling controllers - Nonlinear Transformations - Applications of Gain		

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
	Scheduling, Case Study		
VI	Practical Issues and Implementation - Controller Implementation - Computational Delay - Sampling and Pre- and Post Filtering - Controller Windup - Estimator Implementation - Operational Issues		
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC6104	**Non linear and Adaptive Control systems**			

Course Objectives

1. To study the characteristics of a non-linear system and different types of non-linearities in a system.
2. Should be able to analyze a Non-linear system.
3. Should be able to analyze an adaptive control system with different configurations

Syllabus

Features and Characteristics of non-linear systems- Common non-linearities, Describing function Analysis, Phase plane analysis - Singular points, Construction of Phase portraits, Stability analysis of Nonlinear systems, Liapunov stability analysis, Popov's stability criterion, Circle criterion, Variable structure control systems- Sliding mode control, Development of adaptive control problem, Model Reference Adaptive Systems, Adaptive predictive control. Backstepping

Expected outcome

1. Understand more details about different nonlinearities present in a system.
2. Understand different methods used for analysing a Nonlinear system.
3. Understand more about an adaptive control system schemes

References

1. Jean-Jacques Slotine&WeipingLi,"Applied Nonlinear Control", Prentice- Hall .
2. Shankar Sastry, "Nonlinear System Analysis, Stability and Control", Springer.
3. Hassan K Khalil, "Nonlinear systems", MACMILLAN Publishing company

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Features of linear and non-linear systems- Common non-linearitiesCharacteristics of Nonlinear systems - Limit cycles - stability, jump resonance - Describing function Analysis – Describing function of different non linearities - saturation, dead zone, relay, hysteresis		
II	Phase plane analysis - Singular points – types - Construction of Phase portrits – Isocline, Delta methods.		
FIRST INTERNAL EXAM			
III	Stability analysis of Nonlinear systems, Liapunov stability analysisConstruction of Liapunov function- variable gradient method		
IV	Popov's stability criterion, Circle criterion, Variable structure control systems-basic concepts- Sliding mode control		
SECOND INTERBNAL EXAM			
V	Introduction- Development of adaptive control problem- The role of Index performance(IP) in adaptive systems- Gain scheduling- Model Reference Adaptive Systems- The MIT rule		
VI	Self tuning regulators- Adaptive predictive control. Determination of Adaptation gain Backstepping approach to Stabilization		
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC6892	Mini Project	0-0-4	2`	2016

Course Objectives

To make students Design and develop a system or application in the area of their specialization.

Approach

The student shall present two seminars and submit a report . The first seminar shall highlight the topic, objectives, methodology, design and expected results. The second seminar is the presentation of the work / hardware implementation.

Expected outcome

Upon successful completion of the mini project, the student should be able to

1. Identify and solve various problems associated with designing and implementing a system or application.
2. Test the designed system or application.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6894	Robotics Lab	0-0-2	1	2016

Course Objectives

1. Trajectory planning of robotic manipulators.
2. To track desired trajectories of robotic manipulators and mobile robots.
3. Robot Programming using RAPID
4. Trajectory tracking, Pick & Place, collision avoidance algorithms using RobotStudio
5. Testing of algorithms for trajectory planning, trajectory tracking for robotic manipulators, and localization & path planning of mobile robots using MATLAB

Syllabus

Experiments on 6 DOF Robot- Moving end effector to a point, tracking trajectories in joint space, tracking a trajectories in Cartesian space, Pick & Place operation.

Programming of Robots using RAPID, Familiarisation of Robot Studio- creating a mechanism, trajectory tracking, reachability, collision avoidance experiments using RobotStudio.

Experiments on differentially driven robot- Open loop and closed loop control - moving to a destination, tracking straight line & circular trajectories, Monte-Carlo localization.

Fundamental algorithms in MATLAB - for trajectory generation in one dimensional and multidimensional space, steered mobile robots- moving to a point, following a line, following any path, moving to a pose, trajectory tracking of flying robots, Reactive Navigation, Path planning - D*, RRTs., Localization-Dead reckoning, Monte-Carlo localization, simple walking robot, modelling & control schemes of robots.

PLC programming- AND, OR logic, concept of latching, different types of Timers and Counters, Programming examples with Indralogic L20 PLC, Interfacing with hydraulic/pneumatic systems.

Expected Outcomes

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

1. Plan trajectories for robotic manipulators and mobile robots.
2. Track trajectories for robotic manipulators and mobile robots.
3. Program robots for a specific application.
4. Analyse kinematic and dynamic models of robots.
5. Design and implement controllers for robots.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7115	Advanced Design Synthesis	0-0-4	4	2016

Course Objectives

- To give an overview of the techniques used in Mechanical Engineering for the analysis and synthesis of Mechanisms.
- To familiarize the graphical and analytical techniques commonly used in the synthesis of mechanisms.
- To provide sufficient theoretical background to understand contemporary mechanism design techniques.
- To develop skills for applying these theories in practice.
- Identify mechanisms by type of motion (Planar, Spatial etc.)
- Select the best type of mechanism for a specific application and apply the fundamental synthesis technique to properly dimension the mechanism

Syllabus

Floating Link, Overlay method, Coupler curves - Inflection circle, Transmission angle - Two point synthesis and Three point synthesis of Mechanisms - Synthesis with Four accuracy points. - Synthesis using Displacement Equations.- Synthesis using Complex numbers, Spatial mechanisms

Expected outcome

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

- Create and analyses a great number of types of mechanisms.
- Do Kinematic analysis of common mechanisms used in machinery.
- Apply the analysis and synthesis methods to design a mechanism.

References

1. Kinematic synthesis of Linkages by Richard.S.Hartenberg, Jacques Denavit, McGraw Hill book company.

2. Kinematics and linkage design by Allen. S. Hall. Prentice Hall of India, Ltd.

3. Theory of Mechanisms and Machines by Shigley, McGraw Hill International Edition.

4. Dynamics of Machinery by A.R.Holowenko.

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination

I	Floating Link, Special methods of Velocity and Acceleration Analysis using auxiliary points, overlay method for conditioned crank mechanisms, coupler curves. Roberts – chebyshev theorem	8	15
II	Inflection circle, Euler Savery equation, Hartman construction, Bobillier construction, Synthesis using Optimum transmission angle.	8	15
FIRST INTERNAL EXAM			
III	Geometric methods of synthesis with three accuracy points:- poles of four bar linkages, Relative poles of four bar linkages, Function generators, poles of slider crank mechanisms, Relative poles of slider crank mechanisms, Rectilinear recorder mechanisms. Synthesis of slider crank mechanism with three accuracy points	9	15
IV	Geometric methods of synthesis with four accuracy points:- pole triangles, center point curves, Circle point curves, Construction of circle points, Cardinal points, opposite poles, Pole quadrilaterals, Function Generators, Synthesis of slider crank mechanism with four accuracy points.	10	15
SECOND INTERBNAL EXAM			
V	Algebraic methods of synthesis using displacement equations: - Crank and follower synthesis- three accuracy points, Crank and follower synthesis- angular velocities and accelerations.	10	20
VI	Rectilinear mechanisms, Algebraic methods of synthesis using complex numbers. Spatial motion and spatial linkages, Types of spatial mechanisms, Single loop linkage and multiple loop linkages. Simple mechanisms in Robots	10	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC7811	Robot Vision	**3-0-0**	**3**	**2016**

Course Objectives

1. Introduce the standard computer vision problems and identify the solution methodologies.

Syllabus

Image Formation, Depth estimation and multiview cameras, feature extraction, Segmentation, Pattern analysis, Motion Analysis, Object Detection and Recognition.

Expected Outcome

1. Understand and implement the algorithms for 3D reconstruction from various cues.
2. Understand and implement the various segmentation, pattern analysis, objection detection/recognition methods.

Text Book

1. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer 2010
2. Computer vision: A modern approach, by Forsyth and Ponce. Prentice Hall, 2002.
3. Computer & Machine Vision: Theory Algorithms Practicalities, E. R. Davies, ELSEIVER, Academic Press, 2012
4. Multiple View Geometry in Computer Vision, Richard Hartley and Andrew Zisserman, Second Edition, Cambridge University Press, March 2004

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Fundamentals of Image Formation: Camera- Pinhole and thin lens Model, Depth of field, field of view; Transformation- Orthogonal, Euclidean, Affine, Projective, etc.; Perspective Projection; Homogeneous Coordinates; Vanishing points; Orthographic projection; Parallel Projection.	7	15
II	Image processing fundamentals: Two dimensional orthogonal transforms - DFT, FFT, KLT, DCT. Image enhancement - filters in spatial and frequency domains, histogram equalization. Depth estimation: Binocular Stereopsis; 3D Reconstruction-Photometric Stereo, Shape from shading- Propagation and Optimization Method, Frankot Chellappa Algorithm; Two view geometry- Epipolar geometry, Fundamental matrix, Essential Matrix, Triangulation.	8	15
FIRST INTERNAL EXAM			
III	Feature Extraction: Edges - Canny, LOG, DOG; Line detector-Hough Transform; Corners - Harris and Hessian; SIFT, SURF, HOG.	7	15
IV	Image Segmentation and Pattern Analysis : Image Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Clustering: K-Means; Dimensionality Reduction: PCA.	7	15
SECOND INTERNAL EXAM			
V	Motion Analysis: Background Subtraction and Modeling; Optical Flow: Horn schunck Algorithm and Lucas Kanade Method; Depth from optical flow.	6	20
VI	Object Detection and Recognition - Face detection, Pedestrian detection, Face recognition, Eigen faces	7	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC7321	Foundations of Deep Learning	3-0-0	3	2018

Pre-requisite: Fundamentals of linear algebra, Probability and Random process.

Course Objectives :
The purpose of this course is:-

1. Understand the basic theory underlying machine learning.
2. To learn the foundations of deep learning for computer vision and understand how to build neural networks.
3. Understand major technology trends driving deep learning.
4. Get proficient in convolutional neural networks and its applications.

Syllabus

Machine Learning Basics, Machine learning system design, Neural Networks, Convolutional Neural Networks , Recurrent Neural Networks, Generative Networks

Expected Outcome

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

1. Understand complexity of Machine Learning algorithms and their limitations.
2. Ability to select and implement machine learning techniques and computing environment that are suitable for the applications under consideration.
3. To understand the fundamentals of deep learning.
4. Be able to design and implement deep neural network systems to produce amazing solutions to computer vision challenges.
5. Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains

Text Book

- Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016
- Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Introduction to Statistical Learning, Springer, 2013.
- Michael Nielsen, Neural Networks and Deep Learning

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

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	**Machine Learning Basics**: Learning Algorithms, Over fitting and Under fitting, Hyper parameters and Validation Sets, Estimators, Bias and Variance, Maximum Likelihood Estimation, Bayesian Statistics, Supervised Learning Algorithms, Unsupervised Learning Algorithms, Challenges Motivating Deep Learning. Introduction to python programming and Numpy	7	15
II	**Machine Learning System Design:** Data-driven Approach, K-nearest neighbour. Linear classification:_Loss function, Multiclass SVM, Softmax classifier. Image features optimization, Stochastic Gradient Descent. Implementing a machine learning system for a real world classification problem using python and scikitlibrary.	6	15
FIRST INTERNAL EXAM			
III	**Neural Networks**: Model of a biological neuron, activation functions, Back propagation, Learning XOR, Gradient-Based Learning. Training Neural Networks: Initialization, dropout, batch normalization, Update rules, ensembles, data augmentation, transfer learning. Introduction to pytorch /tensorflow. Implementing image classification algorithms on CIFAR10 dataset using pytorch	6	15
IV	**Convolutional Neural Networks**: Convolution / Pooling Layers, spatial arrangement, layer patterns, layer sizing patterns. LeNet/AlexNet/ZFNet/VGGNet/ResNet case studies, computational considerations, Understanding and Visualizing Convolutional Neural Networks. Applications of CNN- Object Detection. Implementing object classification and detection using CNN networks in python using any of deep libraries like Tensorflow, Keras, Caffe.	7	15
SECOND INTERNAL EXAM			
V	**Recurrent Neural Networks**: RNN, Bidirectional RNNs, Deep Recurrent Networks, Recursive Neural Networks, LSTM, GRU. Image captioning, word prediction.	8	20
VI	**Generative Networks**: Autoencoders, Generative Models, GANs framework, GANs application, Variational auto encoders, DCGANS.	9	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7791	SEMINAR II	**0-0-2**	2	2016

Course Objectives

To make students
1. Identify the current topics in the specific stream.
2. Collect the recent publications related to the identified topics.
3. Do a detailed study of a selected topic based on current journals, published papers and books.
4. Present a seminar on the selected topic on which a detailed study has been done.
5. Improve the writing and presentation skills.

Approach

Students shall make a presentation for 20-25 minutes based on the detailed study of the topic and submit a report based on the study.

Expected outcome

Expected Outcome
Upon successful completion of the seminar, the student should be able to
1. Get good exposure in the current topics in the specific stream.
2. Improve the writing and presentation skills.
3. . Explore domains of interest so as to pursue the course project.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC7893	PROJECT (PHASE 1)	**0-0-12**	6	2016

Course Objectives

To make students

1. Do an original and independent study on the area of specialization.
2. Explore in depth a subject of his/her own choice.
3. Start the preliminary background studies towards the project by conducting literature survey in the relevant field.
4. Broadly identify the area of the project work, familiarize with the tools required for the design and analysis of the project.
5. Plan the experimental platform, if any, required for project work.

Approach

The student has to present two seminars and submit an interim Project report. The first seminar would highlight the topic, objectives, methodology and expected results. The first seminar shall be conducted in the first half of this semester. The second seminar is the presentation of the interim project report of the work completed and scope of the work which has to be accomplished in the fourth semester.

Expected outcome

Upon successful completion of the project phase 1, the student should be able to
1. Identify the topic, objectives and methodology to carry out the project.
2. Finalize the project plan for their course project.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EC7894	PROJECT (PHASE 2)	**0-0-23**	12	2016

Course Objectives

To continue and complete the project work identified in project phase 1

Approach

There shall be two seminars (a mid term evaluation on the progress of the work and pre submission seminar to assess the quality and quantum of the work). At least one technical paper has to be prepared for possible publication in journals / conferences based on their project work.

Expected outcome

Upon successful completion of the project phase II, the student should be able to

1. Get a good exposure to a domain of interest.
2. Get a good domain and experience to pursue future research activities.