KERALA TECHNOLOGICAL UNIVERSITY

Master of Technology

Curriculum, Syllabus and Course Plan

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

*Note: The branches are restricted to three disciplines.

1. Mechanical Engineering
2. Electrical Engineering
3. Electronics Engineering

SEMESTER 1

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	(hours)Duration	
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	01RA6102	Industrial Automation ME	4-0-0	40	60	3	4
B	01RA6104	Programmable Logic Control and Computer Numerical Control EC	3-0-0	40	60	3	3
C	01RA6106	Control, Programming and Calibrations of Robots EE	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	01RA6192	Mini Project	0-0-4	100			2
U	01RA6194	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
01RA6106	Mechanism and Machine Theory ME
01EE6614	Control of Industrial Drives
01EE6316	Design of Power Electronic System
01EC6112	Design of Embedded Systems
01EC6114	Digital Image Processing and Computer Vision

Elective III	
01ME6126	Advanced Finite Element Methods
01ME61	Condition Monitoring & Maintenance Engineering

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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	01RA7191	Seminar II	0-0-2	100			2
W	01RA7193	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	
01RA7151	Product Design and Development
01RA7153	Automotive Mechatronics

01RA7155	Modelling Simulation and Analysis of Manufacturing Systems
01RA7157	Robot Vision
01RA7159	AI for Robotics
01RA7161	Process and Building Automation Systems
01RA7163	Networking Protocols
01RA7165	Micro Electro Mechanical Systems & Techniques

SEMESTER 4

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credit
					Marks	Duration (hours)	
W	01RA7194	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

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

6.

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
01RA6101	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

7. Robert. J. Schilling , "Fundamentals of robotics – Analysis and control", Prentice Hall of India 1996.
8. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
9. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
10. Ashitava Ghosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
11. 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
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
01RA6103	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	4	15
	Generating Elements- Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification	4	
II	Drive characteristics – Utilizing Elements-- Linear actuator – Types, mounting details, cushioning – power packs –accumulators	7	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	7	15
IV	Electro hydraulic servo valves-Different types-characteristics and performance	7	15
SECOND INTERNAL EXAM			
V	Typical Design methods – sequencing circuits design - combinational logic circuit design-cascade method-Karnaugh map method.	8	20
VI	Electrical control of pneumatic and hydraulic circuits- use of relays, timers, counters, interfacing with PLCs, Proportional control of hydraulic systems	7	20

END SEMESTER EXAM

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01RA6105	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,	**6**	

	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.		**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	**6**	**20**

	pressurized vessels, solid level measurement techniques 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
01RA6111	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
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		