Semester- I
Professional Core (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Program	M. Tech. All Branches
Class, Semester	First Year M. Tech., Semester I
Course Code	7IC501
Course Name	Research Methodology and IPR

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	---	30	20	50	100
		Credits: 3			

Course Objectives

1	To prepare students for undergoing research, identify and formulate the research problems, state the hypothesis, design a research layout, set a research process and methodology.
2	To enable student interpret the results, propose theories, suggest possible/alternative solutions, solve, and prove the solution adapted–logically and analytically, conclude the research findings.
3	To impart knowledge to analyze critically the literature and publish research in conferences, journals and to expose students to research ethics, IPR and Patents

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO1	**Demonstrate** a research solution in respective engineering domain using appropriate Engineering research process and research methodology.	Apply
CO2	**Device** feasible solution to a research problem in respective engineering domain based on economic, social and legal aspects using appropriate research procedures and practices.	Analyze
CO3	**Write** research publication, Dissertation, IPR and patent document.	Create

Module	**Module Contents**	**Hours**
I	**Engineering Research Process** Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Definition, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	6
II	**Research Methodology** Problem statement formulation, resources identification for solution, Experimental and Analytical modelling, Simulations, Numerical and Statistical methods in engineering research. Hypothesis and its testing by different techniques: Z-test etc.,	6
III	**Research Methods** Uni and Multivariate Analysis: ANOVA, Design of Experiments/Taguchi Method, Regression Analysis. Software tools like spreadsheets. Processing and Analysis of Data: Processing Operations, Types of Analysis-Presentation and Interpretation of Data Editing, Classification and Tabulation-	7

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Dr. R.S. Desai 23/8/2023
Applied Mechanics Dept

	Interpretation. Analyse your results and draw conclusions.	
IV	**Research Practices** Effective literature studies approaches, critical analysis, Plagiarism, Research ethics, Mendeley - Reference Management Software. Research communication- Effective Technical Writing, Writing a research article for Journal/conference paper, Technical report, Dissertation/ Thesis report writing, Software used for report writing such as WORD, Latex etc. Presentation techniques for paper/report/seminar. Publishing article in Scopus/SCI/Web of science indexed journal or conference.	7
V	**Intellectual Property Rights (IPR)** Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Ownership of copyright, Term of copyright, Technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. New developments in IPR, Traditional knowledge ,Various Case Studies.	7
VI	**Patents** Patent Rights: Scope of Patent Rights. Various Patent databases. Geographical Indications. Procedure for grants of patents, Patenting under PCT. Licensing and transfer of technology. Administration of Patent System. Introduction to International Scenario: WIPO, TRIPs, Patenting under PCT	6

	Textbooks
1	Kothari C. R, "Research Methodology", 2nd Edition, New Age International, 2004
2	Melville Stuart and Goddard Wayne, "Research Methodology: An Introduction for Science & Engineering Students" Juta and Company Ltd, 2000.
3	Kumar Ranjit, "Research Methodology: A Step-by-Step Guide for beginners", SAGE Publications, 4th Ed.-2014.
	References
1	Merges Robert, Menell Peter, Lemley Mark, "Intellectual Property in New Technological Age", ASPEN Publishers, 2016.
2	Ramappa T., "Intellectual Property Rights Under WTO", S. Chand, 2008
3	Mayall, "Industrial Design", McGraw Hill, 1992.
4	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007
5	Deepak Chopra and Neena Sondhi, Research Methodology : Concepts and cases, Vikas Publishing House, New Delhi
	Useful Links
1	NPTEL :: General - NOC:Introduction to Research
2	Introduction to Research - Course (nptel.ac.in)
3	Qualitative Research Methods And Research Writing - Course (nptel.ac.in)
4	https://onlinecourses.swayam2.ac.in/ntr21_ed23/preview - Academic Research & Report Writing
5	https://www.scopus.com/search/form.uri?display=basic#basic
6	https://onlinecourses.nptel.ac.in/noc21_ge12/preview - Qualitative Research Methods And Research Writing
7	https://onlinecourses.nptel.ac.in/noc21_hs44/preview - Effective Writing
8	https://webofscienceacademy.clarivate.com/learn

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9	https://onlinecourses.swayam2.ac.in/ntr21_ed23/preview - Academic Research & Report Writing
10	https://nptel.ac.in/courses/121/106/121106007/
11	https://www.wipo.int/about-wipo/en/

CO-PO Mapping

	Programme Outcomes (PO)					
	1	**2**	3	4	5	6
CO1	3		1			
CO2			2	3	2	
CO3		3		2		2

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Solapur
28-8-2023
Dr. S. S. Solapure
Associate Professor (IT) Dept.

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7CS501
Course Name	Applied Digital Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To provide the basics of modeling of the physical system, analysis.
2	To provides the methodology of designing the controller with realization.
3	To give an overview of advanced controllers like LQR.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Analyze** various controller structures.	IV	Analyzing
CO2	**Evaluate** controller performance using various control algorithms.	V	Evaluating
CO3	**Design** a controller to meet given performance specification.	VI	Creating

Module	**Module Contents**	**Hours**
I	**Controller Structures** Feed forward controllers, One degree of freedom, Two degree of freedom, Lag-Lead controller, PID Controller, Well behaved signal, Solving Aryabhatta's Identity.	5
II	**Controller Realization** Direct structure, Canonical and non-canonical structure, Cascade and parallel realization, PID controller Implementation, Microcontroller implementation of 1^{st}, 2^{nd} and higher order modules, Choice of Sampling interval.	7
III	**PID Controller** Introduction, sampling, discretization techniques, PID controller, methods of tuning, 2-DOF controller with integral action, bumpless PID controller, PID with filtering, 2-DOF PID, systems with delay.	7
IV	**Pole Placement Controllers** Dead-Beat and Dahlin Control, Pole Placement Controller with performance specifications, Implementation of Unstable Controllers, Internal Model Principle for Robustness, Redefining Good & Bad Polynomials, Comparing 1-DOF & 2-DOF Controllers, Anti Windup Controller, PID Tuning Through Pole Placement Control.	6
V	**Pole Placement Controller with IMC** Smith Predictor, Internal Model Control (IMC), IMC Design for Stable Plants, IMC in Conventional Form for Stable Plants, PID Tuning Through IMC, and IMC design fo unstable plant, LQR through pole placement.	7
VI	**State Space Technique to Control Design** Pole placement, Ackerman formula, controllability, estimators, prediction estimators, observability, current estimators, regulator design, combined control law and estimator, LQR, kalman filter design.	7

Textbooks

Mr. A.N. Inamdar

1	*"Digital Control"*, by Kannan M. Moudgalya, John Wiley and Sons Ltd., 2007.
2	*"Microcontroller Based Applied Digital Control"*, by Dogan Ibrahim, John Wiley and sons Ltd., Edition 2006.
References	
1	*"Digital Control Engineering Analysis and Design"*, by M. Sami Fadali and Antoni Visioli Else vier publication 2nd Edition 2013.
2	*"Discrete Time Control System"* By Katsuhiko Ogata, Pearson Education 2nd Edition 2005.
Useful Links	
1	http://moudgalya.org/

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2			2			
CO3				3		
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment
The assessment is based on MSE, ISE and ESE. MSE shall be typically on modules 1 to 3. ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO. ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6. For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

M/s. A.N. Jamdade

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS502
Course Name	Advanced Process Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To provide the basics of process control.
2	To provides the methodology of modelling the process and close loop control.
3	To provide the design of various types of controllers for single loop and multi loop control system.
4	To give the overview of advanced controllers used in process control and multivariable predictive control.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Calculate** the various models of industrial processes.	III	Applying
CO2	**Analyze** the problems associated with open loop and close loop process control system.	IV	Analyzing
CO3	**Evaluate** the performance of processes with various conventional and advanced controllers.	V	Evaluating
CO4	**Design** various conventional and advanced controllers for the processes.	VI	Creating

Module	**Module Contents**	**Hours**
I	**Introduction to Process Control** Introduction, Design aspects of a process control system, Hardware for a process control system. Mathematical modeling and analysis of processes, Modeling considerations for control purposes, input-output model, degree of freedom, elements of feedback control system.	5
II	**Modeling of Process** Transfer functions and the Input-output models. Dynamic behavior and response of first-order systems, second-order system, Integrating process and higher order systems. Computer Simulation and linearization of systems. Poles-zeros and their effect on process response, processes with time delays. Interacting- non interacting and MIMO processes.	7
III	**PID Control** Dynamic behavior of feedback-controlled process, On-Off Controller, Effect of proportional (P), Integral (I) and derivative (D) control on the response of controlled process, effect of composite control actions, PID controller design, time delay effects, tuning and troubleshooting, model based design, control with two degrees of freedom.	7
IV	**Feed Forward and Ratio Control** Introduction to cascade control, feed forward control and ratio-control. Controller design with steady state and dynamic models. Feedback control of system with large dead time or inverse response. Online controller tuning, time delay compensation and inferential control.	6

V	**MIMO Processes and Control** Multi-input- multi-output processes, degree of freedom and number of controlled and manipulated variables. Singular value analysis, tuning of multiloop PID control. Interaction and decoupling of control loops, relative gain array and selection of loops. Overview of modern control methodologies.	7
VI	**Model Predictive Control** Introduction, prediction and control requirements. SISO model predictive control, predictions for MIMO models. MPC calculations. Single-variable dynamic matrix control (DMC) algorithm, multivariable dynamic matrix control. Internal model control (IMC), smith predictive control. Implementation of MPC.	7

	Textbooks
1	*"Chemical Process Control - An introduction to Theory and Practice"*, by George Stephanopoulos, Prentice-Hall of India, 1st Edition 1984.
2	*"Process Dynamics and Control"* by Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, 2nd Edition, Wiley Publications, 2003.

	References
1	"Process Control - Design Processes and Control System for Dynamic Performance", by Thomas E. Marlin, 2nd Edition, McGraw Hill publication.
2	"Process Control System – Application, Design and Tuning", by F.G. Shinskey, McGraw-Hill Publication, 3rd Edition, 1988.
3	"Process Control Instrumentation Technology", by Curtis D. Johnson, 7th Edition, Pearson Education, 7th Edition. 2003.

	Useful Links
1	https://nptel.ac.in/courses/103105064
2	https://archive.nptel.ac.in/courses/103/101/103101142/

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			1			
CO2			1			
CO3				2		
CO4				2		1

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

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AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS503
Course Name	Optimal Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To provide the basic concepts of optimal control.
2	To provide the methodology of designing LQR and LQT optimal control.
3	To give the overview of optimization in constrained and non-constrained controls.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Apply** various concepts of optimal control.	III	Applying
CO2	**Analyze** the systems using LQR and LQT optimal control.	IV	Analyzing
CO3	**Design** of optimal control in constrained and non-constrained systems.	VI	Creating

Module	**Module Contents**	**Hours**
I	**Introduction to Optimal Control** Classical and Modern Control, Optimization, Optimal Control, Plant, Performance Index, Constraints, Calculus of Variations.	5
II	**Calculus of Variations and Optimal Control** Optimum of a Function and a Functional , Basic Variational Problem, Fixed-End Time and Fixed-End State System , Euler-Lagrange Equation ,Different Cases for Euler-Lagrange Equation ,The Second Variation, Extrema of Functions with Conditions ,Direct Method ,Lagrange Multiplier Method ,Extrema of Functionals with Conditions , Terminal Cost Problem.	7
III	**Linear Quadratic Optimal Control Systems** Finite-Time Linear Quadratic Regulator, Riccati Coefficient, Finite-Time Linear Quadratic Regulator: Time-Varying Case, Infinite-Time LQR System.	7
IV	**Linear Quadratic Tracking System** Linear Quadratic Tracking System: Finite-Time Case, LQT System: Infinite-Time Case, Fixed-End-Point Regulator System And Frequency-Domain Interpretation.	6
V	**Constrained Optimal Control Systems** Time-Optimal Control of LTI System, Solution of the TOC System, TOC of a Double Integral System, Fuel-Optimal Control Systems, Energy-Optimal Control Systems. Optimal Control Systems with State Constraints.	7

VI	**Pontryagin Minimum Principle** Constrained System, Pontryagin Minimum Principle, The Hamilton-Jacobi-Bellman Equation, LQR System Using H-J-B Equation.	7

Textbooks	
1	"Optimal Control Systems", by D. S. Naidu, CRC Press, 2002.
References	
1	*"Optimal Control"*, by Frank L Lewis, John Wiley, New York, 1986.
2	*"Optimal Control Theory"*, by Kirk D.E, Dover Publications, 2004.
Useful Links	
1	https://onlinecourses.nptel.ac.in/noc21_ee48/preview

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2				2		
CO3						1

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Professional Core Lab Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS551
Course Name	Applied Digital Control Lab
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	-	30	30	40	100
		Credits: 1			

Course Objectives

1	To provides the basics of modeling of the physical system, analysis.
2	To provide the methodology of designing the controller with realization.
3	To give the overview of advanced controllers like LQR.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Experiment** on closed loop systems using controllers.	III	Applying
CO2	**Analyze** various types of digital controllers.	IV	Analyzing
CO3	**Design** pole placement controllers for various electrical systems.	VI	Creating

List of Experiments / Lab Activities/Topics

List of Lab Activities:

1. Understand the popular controllers and their specifications
2. Design the PID controllers
3. Design pole placement controllers with performance specifications and also PID tuning through pole placement controllers
4. Design pole placement controllers through IMC.
5. Understand terms like stability , calculation of system norms , H2 solution and H∞ solutions
6. Design the kalman filter, LQR and understand state space technique

Textbooks

1	*"Digital Control"*, by Kannan M. Moudgalya, John Wiley and Sons Ltd., 2007.

References

1	Belanger, Control Engineering – Modern Approach, International Edition 1995.
2	Z.Gajic, M. Lelic,Modern Control Systems Engineering, PHI Series in System & Control Engineering 1996
3	TorkelGlaw and LennardLjung Control Theory- Multivariable & Nonlinear Methods, Taylor & Francis Publication London & New York 2002
4	Bernard FriedLand, Advanced Control System Design, Prentice Hall International 2000
5	B.C.Kuo,Digital Control System, 2nd Edition, Oxford Press 2003

Useful Links

1	http://moudgalya.org/

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				2		
CO2			3			
CO3				2		1
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Walchand College of Engineering, Sangli

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AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS552
Course Name	Advanced Process Control Lab
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	-	30	30	40	100
		Credits: 1			

Course Objectives

1	To provide the foundation level knowledge of Process Control.
2	To provide the basics for mathematical model of the process.
3	To provide the knowledge of various types of controller for single loop and multi-loop control system.
4	To provide the knowledge of advanced controllers used in process control.
5	Provide the knowledge of multivariable predictive control.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Determine** the model of process by performing experiments on Process Control System.	II	Understanding
CO2	**Apply** the tuning techniques for various controllers.	III	Applying
CO3	**Evaluate** the performance of given Process Control system.	V	Evaluating
CO4	**Demonstrate** the use of advanced controllers.	III	Applying

List of Experiments / Lab Activities/Topics

List of Lab Activities:

1. Step response of first order system (single capacity system).
2. Step response of multi capacity process (coupled tank system).
3. Closed loop computer controlled pressure control system.
4. Tuning of P PI and PID controllers based on process reaction curve and Ziegler Nichols method.
5. Closed loop computer controlled level control system.
6. Closed loop computer controlled flow control system.
7. Tuning of controllers for level control system.
8. Tuning of controllers for flow control system.
9. Study of cascade controller for a flow control system.
10. Study of PLC and its process controlled applications.

Textbooks

1	George Stephanopoulos, "Chemical Process Control - An introduction to Theory and Practice", Prentice-Hall of India, 1st Edition 1984.

References

1	Thomas E. Marlin, "Process Control - Design Processes and Control System for Dynamic Performance, 2nd Edition", McGraw Hill publication.

2	F.G. Shinskey, "Process Control System – Application, Design and Tuning", McGraw-Hill Publication, 3rd Edition, 1988.
3	Curtis D. Johnson, "Process Control Instrumentation Technology", 7th Edition, Pearson Education, 7th Edition. 2003.
Useful Links	
1	

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			1			
CO2				1		
CO3				2		
CO4						2
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Walchand College of Engineering, Sangli

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AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS553
Course Name	Optimal Control Lab
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	-	30	30	40	100
		Credits: 1			

Course Objectives

1	To provide the basic concepts of optimal control.
2	To provide the methodology of designing LQR and LQT optimal control.
3	To give the overview of optimization in constrained and non-constrained controls.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Apply** various concepts of optimal control.	III	Applying
CO2	**Analyze** the systems using LQR and LQT optimal control.	IV	Analyzing
CO3	**Design** of optimal control in constrained and non-constrained systems.	VI	Creating

List of Experiments / Lab Activities/Topics

List of Lab Activities:

8 experiments based on following using Matlab simulations-

1. Controller Design Based on Parameter Optimization.
2. Optimal Control Based on Calculus of Variations.
3. Optimal Control with Input and State Variable Constraints.
4. Dynamic Programming.
5. Linear-Quadratic (LQ) Optimal Control problem.

Textbooks

1	"Optimal Control Systems", by D. S. Naidu, CRC Press, 2002.

References

1	*"Optimal Control"*, by Frank L Lewis, John Wiley, New York, 1986.
2	*"Optimal Control Theory"*, by Kirk D.E, Dover Publications, 2004.

Useful Links

1	https://onlinecourses.nptel.ac.in/noc21_ee48/preview

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2				2		
CO3						1
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment				
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Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Professional Elective Theory Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS511
Course Name	Professional Elective-I Advanced Digital Signal Processing
Desired Requisites:	Digital Signal Processing

Teaching Scheme		**Examination Scheme (Marks)**			
		MSE	**ISE**	**ESE**	**Total**
Lecture	3 Hrs/week	30	20	50	100
Tutorial	-	**Credits: 3**			

Course Objectives

1	To develop skills for analyzing discrete time signals using transforms.
2	To make students familiar with methods of digital filters design.
3	To develop basic knowledge of random signal processing.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Apply** transforms to discrete time signals for analysis.	III	Applying
CO2	**Analyze** the properties of discrete time systems and random signals processing.	IV	Analyzing
CO3	**Evaluate** digital filters, structures and discrete time random signals.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Discrete time signal and system** Classification of signals, operation on sequences, properties of systems, convolution sum, sampling process.	5
II	**Discrete Time Fourier Transform** DFT, FFT, DIT FFT, DIF FFT algorithm, circular convolution.	7
III	**Digital filter structure** review of z transform, transfer function classification, iir and fir filter characteristics, complementary transfer function, inverse system, digital two-pairs, algebraic stability test, block diagram representation, equivalent structures, fir and iir digital filter structures, all pass filters, lattice structures, all pass realization of iir transfer function.	7
IV	**Digital Filter Design** Butter worth and chebyshev filters, IIR filter design, impulse invariant method, bilinear transformation, FIR filter design.	6
V	**Discrete Time Random Processes** Review of linear algebra, quadratic and hermitian form, random variables, random processes, filtering random processes, special type of random processes.	7
VI	**Signal Modeling** Least square method, pade approximation, prony's method, FIR least square inverse filters.	7

Textbooks

1	"Digital *Signal Processing* " by Sanjit Mitra, Tata McGraw Hill Publication, 3rd Edition, 2008.
2	*"Statiscal Signal Modeling"*, by Monson Hayes, John Wiley 2002.
3	*"Digital Signal processing"*, by Rao&Gejji, Pearson Education, 2nd Edition, 2008.

References	
1	"*Discrete Time Signal Processing*", by Oppenheim Schafer, Ronald, Pearson Education, 2nd Edition, 1999.
2	"*Discrete Signal Processing*", by Ifeachor, Jerris, Pearson Education, 2nd Edition, 2002.
3	"*Digital Signal Processing: A Modern Introduction*'', by Ashok Ambardar, Thomson, 2007.

Useful Links	
1	https://nptel.ac.in/courses/108/101/108101002/

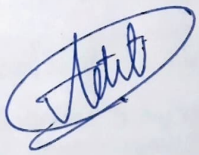
CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				2		
CO2				2		
CO3			1	2		

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)



Walchand College of Engineering, Sangli

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AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS512
Course Name	Professional Elective-I Multivariable Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To provide the basic concepts of Multivariable Control.
2	To provide the methodology of designing Multivariable Control.
3	To give the overview of centralized Multivariable controllers.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Interpret** the basic concepts of Multivariable Control.	III	Applying
CO2	**Analyze** the centralized, decentralized and decoupled control in multivariable control system	IV	Analyzing
CO3	**Evaluate** algorithms for centralized, decentralized, and decoupled control in multivariable control system.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Multivariable Control** Introduction, Process and Instrumentation, process variable, Behavior, control aims, modes of operation, Feedback need, Model based control, Modeling errors, multivariable systems, implementation issue.	5
II	**Linear system models** Introduction, objective, and modeling, first principle, state variable, linear model, I/O representation, system &subsystem, discretized model, equivalence of representation, disturbance model, case study-paper machine head box.	7
III	**Linear system Analysis** Introduction, linear system time response ,stability condition ,discretization ,gains and frequency response , system internal structure ,block system structure, Kalman form, I/O properties, model reduction , key issues in MIMO system analysis Case study -distillation column.	7
IV	**Solution to control problem** Control system design problem, control goal, variable selection, control structure, feedback control, feed forward control, two degree of freedom controller, Hierarchical control, control design issue, case study – ceramic kiln.	6
V	**Decentralized and decoupled control** Introduction, multi-loop control, pairing selection, decoupling, SISO loops with MIMO cascade control, other possibilities, sequential –Hierarchical design and tuning, case study –steam Boiler, Mixing process.	7

VI	**Centralized closed loop control** State feedback, output feedback, rejection of deterministic, unmeasurable disturbance, Augmented plant, process and disturbance models, case study – magnetic suspension.	7

Textbooks	
1	*"Multivariable Control", by* P. Albertos, A. Sala, springer Int. 2008.
2	*"Multivariable Control", by* Z. Bubnicki, springer int. 2005.
3	*"Modeling with Control", by* B. wayne Beguetle,PHI 2008.
References	
1	"*Modern Control System -State variable analyses*", by M. Gopal, TMH Publications, 2010.
Useful Links	
1	https://nptel.ac.in/courses/108/101/108101002/

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2				2		
CO3						1

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS513
Course Name	Professional Elective-II System Identification
Desired Requisites:	Engineering Mathematics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To make students familiar with estimation of parametric, non-parametric models and notions of model quality.
2	To develop skills in students for choosing model structures.
3	To make students develop transfer function and state space models.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Explain** fundamental aspects of system identification.	II	Understanding
CO2	**Apply** system identification for predicting dynamic models.	III	Applying
CO3	**Analyze** models obtained from system identification.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**LTI System:-** Introduction, Step-wise Procedure for Identification, Models and classification, Non-parametric, parametric models, state space descriptions, Sampled data systems.	5
II	**Random Processes** Random variables, Covariance and Correlation, Auto-Correlation and Cross-Correlation functions, Moving Average models, Auto-Regressive models, ARMA models, Spectral representations.	7
III	**Estimation Theory** Introduction to Estimation, Properties of estimator, Estimation methods, Estimation of Signal Properties.	7
IV	**Models and Predictions** General structure of LTI models in identification, Quasi stationarity, Non-parametric models (impulse, step and frequency response), Family of Parametric models, Predictions, One- step ahead prediction,Infinite-step ahead prediction.	6
V	**Input-Output Identification** Estimation of Time-Series Models, Estimation of Impulse/Step (Response) Models, Estimation of Frequency Response Functions, Estimation of Parametric Input-Output Models.	7
VI	**DescribingFunction** Describing function method, jump hysteresis, sufficient condition forexistence and nonexistence of periodic orbits, Describing function fornonlinearities,ideal relaywith hysteresisand deadzone.	7

Textbooks	
1	"*Principles of System Identification Theory and Practice", by* Arun K Tangirala, *CRC Press, 2015.*
2	"*System Identification", by* Sodderstrom & Stoica, *PHI,1989*
References	
1	"*Modeling of Dynamic Systems*", Ljung L, Glad T, *PHI, 1994*
Useful Links	
1	

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				2		
CO2						1
CO3				3		
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment
The assessment is based on MSE, ISE and ESE. MSE shall be typically on modules 1 to 3. ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO. ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6. For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem I
Course Code	7CS516
Course Name	Professional Elective-II Robust Control
Desired Requisites:	Engineering Mathematics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To provide the basic concepts of robust control.
2	To provide the methodology of design of robust control.
3	To give the overview of h-infinity design.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Explain** basic concepts of robust control.	II	Understanding
CO2	**Apply** robust control design and stability analysis.	III	Applying
CO3	**Analyze** the H∞-Control.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Robust Control** Introduction to Basic Concepts, Systems and Signals, Stability of LTI Systems, Controller design, Loop shaping, Closed loop Transfer function loop shaping, Linear Fractional transformations.	5
II	**Stabilizing Controllers** Internal stability, stabilizing controllers, Stabilizing Controllers - State-Space Descriptions, stability analysis in frequency domain, system norms	7
III	**Limitations on Performance** Limitations on performance SISO and MIMO systems, sensitivity, time lags, uncertainties, phase lag, performance requirements imposed by disturbances and commands.	7
IV	**Uncertainty and Robustness** Introduction to robustness, Uncertainties and representation, Configuration, Types of Uncertainties of System Components, SISO Robust performance and Stability.	6
V	**Robust Stability and Performance** General control configuration, representing uncertainty, Introduction to Stability and Robust Performance Test, structured and unstructured uncertainty, SSV, mu-synthesis and DK iteration.	7
VI	**Controller Design** LQG control, H2 and H∞-Control, H∞ loop shaping,, H∞ loop shaping design, introduction to model reduction techniques , balanced realizations, hankel norm approximation, reduction of unstable models.	7

Textbooks

1	*"Essentials of Robust Control"*, by Kemin Zhou, Prentice Hall Publications, 1997.
2	*"Robust and Optimal Control"*, by Kemin Zhou, John Doyle, Feher-Prentice Hall Publications, 1995.
References	
1	"*Robust Control Systems"*, by P. H. Petkov, M.M. Konstantinov, Springer Publications, 2005.
2	*"Multivariable Feedback Control"*, by Sigurd Skogestad, Ian Postlethwaite, Wiley Publications, 2005.
Useful Links	
1	

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
POCO1			3			
CO2				2		
CO3				2		
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment
The assessment is based on MSE, ISE and ESE. MSE shall be typically on modules 1 to 3. ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO. ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6. For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7CS514
Course Name	Electric Vehicle Technology
Desired Requisites:	Electrical Machines, Power Electronics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To develop basic knowledge related to architecture of Electric Vehicles.
2	To provide knowledge related to design aspects and dynamics of Electric Vehicles.
3	The course aims at enabling students to understand the motor specifications and charging standards for Electric vehicles.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Explain** the architecture and features of Electric Vehicles	II	Understanding
CO2	**Illustrate** various topologies of Electric vehicles for different design considerations	III	Applying
CO3	**Compute** the vehicle dynamics for Electric vehicle systems	III	Applying

Module	**Module Contents**	**Hours**
I	**Introduction to Electric Vehicles** Background of Electric Vehicles, Electric Vehicle System, Components of Electric Vehicles, Advantages of Electric Vehicles, Efficiency, Pollution Comparison with conventional vehicles, Fundamentals of Electric Vehicles	5
II	**Types of Electric Vehicles and Architecture of EVs** Concept of Electric, Hybrid and Plug-in Electric Vehicles, Typical configuration of Hybrid Electric Vehicle, Topologies of HEVs: Series, Parallel and Series-Parallel Configuration, Topologies of Plug-in Hybrid Electric Vehicles, Fuel Cell Electric Vehicles, Solar Powered Electric Vehicles	7
III	**Design Considerations for Electric Vehicles** Introduction to EV design fundamentals, Aerodynamic Consideration, Rolling resistance, Transmission efficiency, Consideration of vehicle mass, Basics of Electric vehicle chassis and body design, general issues in Electric vehicle design	7
IV	**Vehicle Dynamics** Roadway fundamentals, Vehicle Kinetics, Dynamics of Vehicle Motion, Propulsion power: Force velocity characteristics, Vehicle gradability, Velocity and Acceleration: Velocity Profile, Distance traversed, tractive power, Energy Required, Propulsion System Design for EV systems	6
V	**Electric Machines in EV systems**	7

	Motor and Engine ratings, EV and HEV motor requirements, Three phase AC machines for Electric vehicles: Induction Machines, SRM machines, PMSM machines, Design aspects for EV systems, Numericals	
VI	**Electric Vehicle Chargers and Charging Standards** EV charging: requirements and Classification, Charging standards for Electric vehicles, Introduction to AC and DC chargers for EV systems, Working of Electric Vehicle Supply Equipment (EVSE), Fast Chargers for EV systems	7

	Textbooks
1	*Iqbal Husain , ' Electric and Hybrid Vehicles: Design Fundamentals ', CRC Press, 2003.*
2	*James Larminie, John Lowry, " Electric Vehicle Technology Explained", Wiley , 2nd edition, 2012*
	References
1	Sheldon Williamson, ' Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles ', Springer-Verlag, 2012
2	M. Ehsani, Y. Gao, S. Gay and A. Emadi , Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 2005.
	Useful Links
1	https://nptel.ac.in/courses/108/103/108103009/
2	https://nptel.ac.in/courses/108/102/108102121/
3	https://nptel.ac.in/courses/108/106/108106170/

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2				2		
CO3						3

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Semester- II
Professional Core (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem II
Course Code	7CS521
Course Name	PLC and Embedded Control
Desired Requisites:	Instrumentation Techniques, Microcontroller and Applications

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	The course intends to exploit the PLC and Embedded Control for industrial automation
2	The course aims at developing programs using ladder logic for industrial automation
3	It intends to analyze the performance of automation systems employing PLC and Embedded Control

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Interpret** features of PLC and Embedded Control Systems used for Industrial Automation.	III	Applying
CO2	**Use** ladder logic programming technique for various PLC applications.	III	Applying
CO3	**Evaluate** the performance of PLC network configurations, PLC functions used for different application	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Introduction to PLC** Introduction, Advantages, Disadvantages, Parts of PLC, PLC Input module, PLC Output Module, PLC Architecture, PLC Operation, PLC as a computer, PLC memory and interfacing, Power Supply for PLC.	5
II	**Laplace Transform and Its Applications** Definition, Transform of Standard functions, Properties, Transform of derivative and Integral, Inverse Laplace Transform, Convolution Theorem, Applications to solve linear differential equations, Laplace transform of periodic functions.	7
III	**Fourier Series** Periodic functions ,Dirichlet's conditions, Definition , Determination of Fourier coefficients (Euler's formulae), Expansion of functions, Even and odd functions, Change of Interval and functions having arbitrary period, Half range Fourier sine and cosine series.	7
IV	**Fourier Transform** Definition, Fourier Sine and Cosine Integral, Fourier sine and Cosine transform, Inverse Fourier sine and Cosine transform, Properties, Parseval's Identity.	6

V	**Partial differential equations and its Application** Partial differential equations, Four standard forms, application to one dimensional Heat equation.	7
VI	**Statistics** Correlation, Linear regression, Curve fitting (a) Straight line (b) Parabolic curve (c) Logarithmic Curve.	7

	Textbooks
1	John W. Webb, Ronald A. Reis, "Programmable logic controllers", principles & applications, PHI publication, Eastern Economic Edition, 1994.
	References
1	John R. Hackworth and Peterson, "PLC controllers programming methods and applications", PHI, 2004.
2	Garydunning,"*IntroductiontoPLC*",Thomsonlearning,EditionIII,2006.
3	WilliamH.Bolton, "*Programmablelogiccontrollers*",Newnes,EditionVI,2006.
	Useful Links
1	https://nptel.ac.in/courses/108/105/108105062/
2	https://nptel.ac.in/courses/108/105/108105063/
3	https://www.sanfoundry.com/100-plc-programming-examples/

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2			3			
CO3			2			
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem II
Course Code	7CS522
Course Name	Non-Linear Dynamical Systems
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To make students familiar with features of nonlinear dynamical systems.
2	To develop skills in students for analyzing the behavior of nonlinear systems.
3	To develop skills in students for evaluating nonlinear system.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Classify** features of nonlinear systems.	III	Applying
CO2	**Examine** behavior of nonlinear systems through various mathematical tools.	IV	Analyzing
CO3	**Recommend** step by step approach for investigating the dynamics of nonlinear systems.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Nonlinear Dynamical Systems** Introduction, some features of nonlinear dynamical systems, first order systems, second order system, equilibrium points, classification of equilibrium points.	8
II	**Differential Equation Solution** Lipschitz functions, locally/globally Lipschitz, existence/uniqueness of solutions, Cauchy sequence, Banach spaces, Bellman Gronwall inequality, Stability of equilibrium point, Stability in sense of Lyapunov, Asymptotic stability, Lyapunov's theorem on stability, Global asymptotic stability, linear systems.	8
III	**Advanced Stability Theory** Extension of Lyapunov's theorem in different context, converse Lyapunov theorem, instability theorem, equilibrium sets, LaSalle's Invariance principle, Barbashin and Krasovskii's theorems	8
IV	**Periodic Orbits** Bendixson criterion and Poincare-Bendixson criterion, Lotka predator prey model, van-der-Pol oscillator, Linearization.	5

V	**Interconnection Between Linear System and Nonlinearities** Signals, operators, norm of signals, finite gain L2 stable, passive filters, dissipation equality, positive real lemma, Kalman Yakubovich-Popov theorem, memoryless nonlinearities, loop transformation, circle criterion, limit cycle, Popov criterion.	6
VI	**Describing Function** Describing function method, jump hysteresis, sufficient condition for existence and nonexistence of periodic orbits, Describing function for nonlinearities, ideal relay with hysteresis and dead zone.	4

	Textbooks
1	H. K. Khalil, "*Nonlinear systems*",Prentice Hall, 3rd Edition 2002.
2	Jean-Jacques E.Slotine &Weiping Li, "*Applied Nonlinear Control*", by Prentice Hall, 1991.
	References
1	Shankar Sastry,"*Nonlinear Systems:Analysis, Stability and Control*", Springer,New-York,1999.
2	M. Vidyasagar, "*Nonlinear Systems Analysis*", Prentice-Hall,1993.
	Useful Links
1	https://nptel.ac.in/courses/108/101/108101002/

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2				3		
CO3						2

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem II
Course Code	7CS523
Course Name	Professional Elective 3:Adaptive Control
Desired Requisites:	Applied Digital Control

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	This course provides the basic concepts of modern control techniques for controller design
2	It provides the methodology of design control optimization in estimation for Adaptive control.
3	It gives the overview of adaptive control design algorithms.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Analyze** modern and adaptive control techniques for controller design	IV	Analyzing
CO2	**Evaluate** various adaptive control algorithms.	V	Evaluating
CO3	**Design** various adaptive controllers like MRAC, STR and LQG.	VI	Creating

Module	**Module Contents**	**Hours**
I	**Identification** Introduction, least square estimation, time series, ARMA process, prediction and error models, statistical properties of parameter estimation, frequency domain interpretation, noise model, Identification of heating tank, maximum likelihood estimation.	5
II	**Minimum Variance Control** K-step ahead prediction error model, ARMAX, white noise model, ARIMAX model, minimum variance controller, control low for non-minimum phase system, minimum variance control low, generalized minimum variance controller, ARMAX and ARIMAX model, PID Tuning through GMVC control.	7
III	**Model Predictive Control** Model predictive control-introduction, generalized predictive control, noise model, ARIMAX model, gamma GPC, model derivation, optimization of objective function, predictive PID, dynamic matrix control.	7
IV	**Adaptive Control Schemes** Adaptive control- introduction, adaptive schemes, adaptive control problem, deterministic self-tuning regulators, pole placement design, continuous and direct self-tuning, minimum variance and moving average controllers, stochastic self-tuning regulators, neural network and fuzzy adaptive control scheme.	6

V	**MRAC** Model reference adaptive control-introduction, MIT rule, determination of adaptive gain, lyapunov theory, model reference adaptive system using lyapunov, application to adaptive control problem, relation between STR and MRAC system, stochastic, adaptive control system.	7
VI	**Linear Quadratic Gaussian Control** Linear quadratic Gaussian control- introduction, spectral factorization, controller design, simplified LQG control, performance analysis of controllers, state space approach to regulator design, linear quadratic regulator, kalman filter design.	7

	Textbooks
1	Kannan M. Moudgalya, "Digital Control", TMH publications, 2007.

	References
1	Astrom, Wittenmark, "*Adaptive Control*", Pearson Education,1995.
2	Petros Ioannous, Jing Sun, "*Robust adaptive Control*", Prentice Hall Int.Ed.,1996.
3	B. N. Chatterji, K. K. Permar, "*System Identification*", Oxford and IBH publications, 1990.

	Useful Links
1	NPTEL Course

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2			2			
CO3				3		1

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Professional Core (Lab) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem II
Course Code	7CS571
Course Name	PLC and Embedded Control Lab
Desired Requisites:	Instrumentation Techniques, Electrical Measurements Lab, Microcontroller and Applications Lab

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	-	30	30	40	100
		Credits: 1			

Course Objectives

1	The lab course is aimed to develop programming skills using PLC for Industrial Automation
2	The course intends to introduce the use of PLC for solving real world problems.
3	It will enable students to use PLC for control applications in electrical engineering

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Execute** experiments based on PLC systems.	III	Applying
CO2	**Construct** basic control systems using PLCs.	IV	Analyzing
CO3	**Design** ladder logic programs for various PLC applications.	VI	Creating

List of Experiments / Lab Activities/Topics

List of Lab Activities:

There will be ten to twelve practicals covering PLC-SCADA. These experiments are carried out in simulated environment by drawing the ladder diagram, programming and simulation, writing ladder for representative industrial automation systems and simulation study. Developing GUI and linking it to the ladder diagram. A mini project is to be carried out based on the skills acquired during practicals

1. Use different components of Relay and PLC logic.
2. Implement ladder diagram for ON/OFF and latching functions.
3. Design of PLC program for motor reversal control.
4. Illustrate stair case lighting using PLC programming.
5. Implement PLC program for building automation.
6. Design of PLC program for various arithmetical functions.
7. Devise the PLC program for traffic control system.
8. Design of ON/ OFF control mechanism using PLC timer functions.
9. Design of basic applications employing PLC counter functions.
10. Design of basic applications employing PLC analog inputs.

Textbooks

1	John W. Webb, Ronald A. Reis, "*Programmable logic controllers, principles & applications*", PHI publication, Eastern Economic Edition,1994.

References

1	John R. Hackworth and Peterson, "*PLC controllers programming methods and applications*", PHI, 2004.
2	Garydunning, "*Introduction to PLC*", Thomson learning, Edition III,2006.

3	William H. Bolton, "*Programmable logic controllers*", Newnes , Edition VI, 2006.

Useful Links	
1	https://nptel.ac.in/courses/108/105/108105062/
2	https://nptel.ac.in/courses/108/105/108105063/
3	https://www.sanfoundry.com/100-plc-programming-examples/

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			2			
CO2				2		
CO3				2		

The strength of mapping is to be written as1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%

Assessment	Based on	Conducted by	Typical Schedule	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40

Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7CS572
Course Name	Non-Linear Dynamical Systems Lab
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	--	30	30	40	100
		Credits: 1			

Course Objectives

1	To make students simulate nonlinear system for analyzing its properties.
2	To develop skills in programming for determining stability of nonlinear system.
3	To make students understand the behavior of Periodic orbit through programming and simulation.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Demonstrate** the properties of nonlinear systems using simulation.	III	Applying
CO2	**Analyze** the stability of nonlinear system using programming and simulation tools.	IV	Analyzing
CO3	**Evaluate** the behavior of periodic orbit using programming and simulation tools.	V	Evaluating

List of Experiments / Lab Activities/Topics

List of Lab Activities:

Lab activities/Lab performance shall include mini-project, presentations, drawings, case studies, report writing, site visit, lab experiment, tutorials, assignments, group discussion, programming and other suitable activities, as per the nature and requirement of the lab course.

1. To simulate the effects of various non-linearities on system using MATLAB
2. To simulate linear and non-linear differential equations using MATLAB
3. Constructing phase portrait of linear system using MATLAB
4. Constructing phase portrait of non-linear system using MATLAB
5. Study of limit cycle using MATLAB Simulink
6. Simulation of predicting limit cycle using describing function analysis.
7. Study of Cart mounted Inverted Pendulum system.
8. Stability analysis using MATLAB.
9. Coding for constructing phase portrait of non-linear system.

Textbooks

1	Jean-Jacques E. Slotine & Weiping Li., "*Applied Nonlinear Control*", Prentice Hall, 1991.

References

1	H. K. Khalil, "*Nonlinear systems*",3rd Edition, Prentice Hall, 2002.
2	Vukic, kuljaca, Donlagic, "*Nonlinear control systems*", Marcel Dekker publisher, 2003.

Useful Links	
1	https://nptel.ac.in/courses/108/101/108101002/

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				2		
CO2				2		
CO3						2
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech (Control System Engineering)
Class, Semester	First Year M. Tech, Sem II
Course Code	7CS545
Course Name	Seminar
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	--	30	30	40	100
		Credits: 1			

Course Objectives

1	To understand industrial problems.
2	To suggest engineering solutions to the defined problem.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	Course Outcome Statement/s	Bloom's Taxonomy Level	Bloom's Taxonomy Description
CO1	**Chose, Formulate** a clear problem.	III	Applying
CO2	**Select and apply** appropriate engineering methods and tools for solving the problem.	VI	Creating
CO3	**Develop** the project and its results following an established project methodology.	V	Evaluating
CO4	**Present** the project results.	IV	Analyzing

List of Experiments / Lab Activities/Topics

List of Lab Activities:

The Industry project will involve the selection of appropriate real time industry problem by understanding the working of particular industry application. Formulate the problem, select design and methodology to find the solution. Construct an electrical system by using appropriate hardware software tools. Each student should conceive, design and develop the idea leading to a project/product. The student should submit a soft bound report at the end of the semester. The final product as a result of Industry project should be demonstrated in phases at the time of examination.

This will help student to understand structured management in industry, sustainable development, with consideration to both scientific and ethical aspects and its presentation with technical report.

Textbooks

1	To be used based on selected project

References

1	Industry 4.0 : fourth Industrial Revolution guide to Industry 4.0

Useful Links

1	

CO-PO Mapping						
	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2				
CO2				2		2
CO3			2			
The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High Each CO of the course must map to atleast one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Semester- II
Professional Elective (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7CS532
Course Name	Professional Elective 4 : Robotics and AI
Desired Requisites:	Electrical Machines, Instrumentation, Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives

1	This course provides the basics of robot control.
2	It provides the methodology of modelling and control the robot.
3	It also provides the design of various types of robot controllers

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Analyze** various models of robots and their dynamics.	IV	Analysing
CO2	**Analyze** problems associated with open loop and closed loop robot control system	IV	Analysing
CO3	**Design** various conventional and advanced controllers for robotics.	VI	Creating

Module	**Module Contents**	**Hours**
I	**Introduction** Introduction -- brief history, types, classification and usage Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms.	5
II	**Elements of robots – joints, links, actuators, and sensors** Different kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor. Types of transmissions, Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors, and vision	7
III	**Kinematics of robots** Introduction, Direct and inverse kinematics problems, Examples of kinematics of common serial manipulators, workspace of a serial robot, Inverse kinematics of constrained and redundant robots. Degrees-of-freedom of parallel mechanisms and manipulators, Active and passive joints, Constraint and loop-closure equations, Direct kinematics problem, Mobility of parallel manipulators, Closed-from and numerical solution, Inverse kinematics of parallel manipulators and mechanisms.	7

IV	**Velocity and statics of robot manipulators** Linear and angular velocity of links, Velocity propagation, Manipulator Jacobians for serial and parallel manipulators, Velocity ellipse and ellipsoids, Singularity analysis for serial and parallel manipulators, Mass and inertia of links, Lagrangian formulation for equations of motion for serial and parallel manipulators.	6
V	**Motion planning and control** Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator, Non-linear model based control schemes, Simulation and experimental case studies on serial and parallel manipulators, Control of constrained manipulators, Cartesian control, Force control and hybrid position/force control, Advanced topics in non-linear control of manipulators.	7
VI	**AI in Robotics** Models of flexible links and joints, Kinematic modeling of multi-link flexible robots, Dynamics and control of flexible link manipulators. Advanced control using AI techniques, Fuzzy control, Neural control, Adaptive control and implementation issues.	7

	Textbooks
1	Ashitava Ghosal,' *Robotics: Fundamental Concepts and Analysis'*, 2nd Edition, Oxford University Press, 2008.
2	Mittal R. and Nagrath I., '*Robotics and Control'*, McGraw-Hill publications, 2017.
	References
1	Craig,,' *Introduction to Robotics: Mechanics and Control'*, 3rd Edition, Oxford University Press, 2008
	Useful Links
1	

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				2		
CO2				2		
CO3			2			1

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7CS531
Course Name	Professional Elective 3 : Modern Power Electronics
Desired Requisites:	Power Electronics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives

1	It is aimed to impart skills of analysis for different types of advanced converters and shunt active power filters.
2	Make the students acquainted with control strategies of different types of advanced converters and shunt active power filters.
3	To make aware of research avenues in the field of power electronics.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Interpret** configuration and working of various Power Electronic converters.	III	Applying
CO2	**Analyze** various Power Electronic converters and systems.	IV	Analyzing
CO3	**Evaluate** various power electronic systems using power electronic converters.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**PWM rectifiers** Advantages & disadvantages of three phase thyristor converter, Single phase and three phase VSI PWM converters working, types, Control of PWM rectifiers, analysis and application. Three phase CSI PWM converter, control and applications.	5
II	**Multilevel inverters** Three phase two level Voltage source inverter, various PWM methods, Multilevel Voltage source inverter, Types: Diode clamp multilevel inverter, flying capacitor multilevel inverter, cascaded multilevel inverter, applications of multilevel inverters, comparison of multilevel inverter. Control method: Multiple carrier PWM for MLI	7
III	**Resonant pulse inverters** Series resonant inverter with unidirectional and bi-directional switches, parallel resonant inverters, voltage control of resonant inverters, zero current and zero voltage switching resonant converters, two-quadrant ZVS resonant converters, resonant DC link inverters and control technique.	7

IV	**Photovoltaic Inverters** Photovoltaic Inverters structures derived from H bridge topology such as H5 inverter, Heric inverter, REFU inverter, full bridge inverter with DC bypass, inverter structures derived from NPC topology such as neutral point clamped half bridge inverter, conergy NPC inverter, three phase PV inverter.	6
V	**Matrix Converters and Z source inverters** Topology, working and control methods of Matrix converters, Various circuit topologies and control of Z source inverter, Application of Z source in induction motor control.	7
VI	**Active power filters** Power Quality Issues due to power Electronics, Introduction to active power filter, types of active power filters overall control of shunt active power filter, control of shunt active filter based on SRF theory. Control of shunt active filter based on instantaneous power theory. harmonic compensation & reactive power compensation.	7

	Textbooks
1	M. H. Rashid, "*Power Electronics: circuits devices and applications*", Pearson Education, Third edition.
	References
1	B. K. Bose, "*Modern Power Electronics and AC drives*", PHIPL, New Delhi.
2	M. B. Patil, V. Ramayanan and V. T. Ranganathan, "*Simulation of Power Electronics circuits*", Narosa publication.
3	Remus Teodorescu, Marco Liserre and Pedro Rodrigues, "*Grid- Converters for Photovoltaic and Wind Power Converters*", A john Wiley and sons Ltd., first edition 2011.
4	NPTEL lectures on Advanced Power Electronics
	Useful Links
1	

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			1			
CO2				1		
CO3				2		1

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7CS532
Course Name	Professional Elective 3: Artificial Intelligence in Industrial Automation
Desired Requisites:	Electrical Machines, Instrumentation, Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives

1	To identify potential areas for automation and justify need for automation
2	Study the concepts of Artificial Intelligence.
3	Learn the methods of solving problems using Artificial Intelligence.
4	Apply the concepts of AI to attain industrial automation

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Understand basic AI algorithms.	II	Understanding
CO2	Identify appropriate AI methods to solve a given problem.	IV	Analyzing
CO3	Acquire knowledge about AI/ ML/DL techniques in Industrial automation.	III	Applying
CO4	Understand the levels of automation.	II	Understanding

Module	**Module Contents**	**Hours**
I	**Introduction to Artificial Intelligence** Introduction - Foundations of AI- History of AI Intelligent agents: Agents and Environment- Reactive agent- deliberative- goal-driven, utility driven, and learning agents.	5
II	**Machine learning** Supervised learning– Classification Methods-Nearest neighbor- Decision trees-Linear discriminant Analysis - Logistic regression- Support Vector Machines Unsupervised learning: Clustering- Clustering Methods-Partitioned based Clustering - K-means- K-medoids; Hierarchical Clustering - Agglomerative- Divisive- Distance measures.	7
III	**Neural Networks** Structure and function of a single neuron; Artificial Neural Networks (ANN); Single-layer networks; Perceptron-Linear separability, Training algorithm, Limitations; Multi-layer networks-Architecture, Back Propagation Algorithm (BTA) training algorithms; Recurrent Networks; Feed- forward networks; Radial-Basis-Function (RBF) networks.	7
IV	**Typical applications of ANNs** Classification, Function Approximation, Forecasting, Control, Optimization. - Reinforcement learning, Basics of Deep Learning-CNN-LSTM.	6
V	**Applications of Artificial Intelligence** ML and DL models in Manufacturing-Health Monitoring- Predictive Maintenance.	7

VI	**Automation** Introduction - Automation in Production System, Principles and Strategies of Automation, Basic elements of an Automated System, Advanced Automation Functions, Levels of Automations. Flow lines & Transfer Mechanisms, Fundamentals of Transfer Lines. (SLE: Analysis of Transfer Lines). Automated	7

	Textbooks
1	Rich and Knight, "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2014.
2	Ethem Alpaydin, "Machine Learning the New AI", MIT press, 2016.

	References
1	Ian Good Fellow, Yoshua Bengio, Aaron Courville, DEEP LEARNING - The MIT Press (18 November 2016).
2	Stuart Russell and Peter Norvig, "Artificial Intelligence - A Modern Approach", 4th Edition, Pearson, 2020.
3	Richard E. Neapolitan, and Xia Jiang, "Artificial Intelligence -With an Introduction to Machine Learning", 2nd Edition, CRC press, 2018.
4	Anuradha Srinivasaraghavan, Vincy Joseph "Machine Learning", Wiley, 2019
5	Wolfgang Ertel," Introduction to Artificial Intelligence", Second Edition, Springer, 2017.
6	Rajiv Chopra, "Deep Learning", 1st edition, Khanna Publishing House, 2018.
7	Deepak Khemani, "A First Course in Artificial Intelligence", McGraw Hill Education, 2013.

	Useful Links
1	NPTEL lectures on Machine learning and Deep Learning.

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3					
CO2		3				
CO3		3				

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7CS533
Course Name	Professional Elective 4 : Neural Network and Fuzzy Control
Desired Requisites:	Electrical Machines, Instrumentation, Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	1	30	20	50	100
		Credits: 4			

Course Objectives

1	This course provides the basic concepts of Neural Networks and Fuzzy Control
2	It provides the methodology of design Neural Networks and Fuzzy control.
3	It gives the overview of genetic algorithms and applications development.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Explain** Neural Networks and Fuzzy Control.	II	Understanding
CO2	**Apply** genetic algorithms and optimization in NN, fuzzy applications development.	III	Applying
CO3	**Analyze** Neural Networks and Fuzzy Controller algorithms.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Neural Network** Neuron model & architectures, Learning rule, Training multiple Neuron, convergence, Performance surfaces & optimum points, Taylor's series & directives & minimum values, Quadratic functions, Performance optimization, Steepest descent, Newton method, Conjugate gradients.	5
II	**Supervised Learning Networks** Adaline network, Mean square error, LMS algorithm, Analysis of convergence, MLPs, back propagation, Choice of network architecture, Convergence, Drawbacks & modification of BPN, Application to control.	7
III	**Unsupervised Learning Networks** Associative learning- simple associative learning, Unsupervised Hebb, Modifications in Hebb, Instar and out star rule, Application to control.	7
IV	**Fuzzy Logic** Fuzzy mathematics, Fuzzy mapping, Fuzzy relations, Implication rules, Mamdani & Sugeno models, Fuzzy rule Base structure, FKBS systems, FKBC PID.	6
V	**Fuzzy Controller Design** Mamdani techniques, Takagi Sugeno Model, PDC techniques, Stability Analysis using matrix inequality, Application and implementation.	7

VI	**Genetic-Neuro-Fuzzy System** Optimization, Genetic Algorithm, Theory of GA, Processes involve in genetic optimizations, Applications of genetic algorithm, Neural-fuzzy combinations, Fuzzy GA combinations.	7

	Textbooks
1	M. T. Hagan, H. B. Demuth, M. H. Beale, "*Neural Network Design*", PWS Publications, 1996
2	Timothy J. ross , "*Fuzzy Logic with Engineering Applications*", Pearson Publications, 2010
	References
1	Driankov, "*Fuzzy Control*", Narosa Publications, 2000
2	B. Yegnanarayana, "*Artificial Neural Networks*", PHI Publications, 2008
3	Simon Haykin, "*Neural Networks and Learning Machines*", Pearson-PHI publications, 2009.
	Useful Links
1	https://onlinecourses.nptel.ac.in/noc21_ge07/preview

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2				2		
CO3				2		

The strength of mapping is to be writtenas1,2,3;Where,1:Low,2:Medium,3:High
Each CO of the course must map to atleast one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7CS534
Course Name	Professional Elective 4: Modern Signal Processing
Desired Requisites:	Digital Signal Processing

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives

1	This course provides the basic concepts of least square algorithms and its applications to adaptive signal processing.
2	It provides the methodology of the adaptive filter theory and applications.
3	It is intended to design of Kalman filter and implementation issues.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Apply** the least square algorithms to adaptive signal processing	III	Applying
CO2	**Use** of Embedded processors for DSP applications	III	Applying
CO3	**Analyze** adaptive and kalman filter.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Statistical Signal Processing Algorithms:** Steepest descent algorithm- wiener filter, w-h equations, basic idea of steepest descent algorithm, algorithm applied to wiener filter, stability of steepest descent algorithm, deterministic search method, limitation of algorithm.	5
II	**Least Means Square Algorithms:** Least mean square adaptive algorithm-LMS adaptation algorithm, statistical LMS theory, comparison of LMS with steepest descent algorithm, adaptive prediction, convergence of algorithm, robustness of LMS filter, h-infinity criterion, upper bound of step size parameter, transfer function approach for deterministic input.	7
III	**Recursive Least Means Square Algorithms:** Normalized LMS and recursive adaptive algorithm- normalized LMS algorithm, constrained optimization problem, stability of normalized LMS algorithm, step size control, convergence process, RLS algorithm, weighted RLS algorithm, update recursion, convergence analysis, robustness of RLS algorithm.	7
IV	**Kalman Filter:** Kalman filter-introduction, recursive minimum mean square estimation , Kalman filter problem, innovation process, estimation of state, Kalman filtering, initial conditions, Kalman and RLS filter , variants of Kalman filter, extended Kalman filter	6

V	**Digital Signal Processors:** Programmable DSPs-overview of embedded systems, DSP processors, architecture, instructions, pipelining and memory management, controls, interrupts and event managers, Texas instruments chips-6713 applications	7
VI	**DSP based Motor Control:** DSP for control applications- DSPs in control applications, Texas instruments chips-2407 , architecture and instructions, interrupts and event managers ,peripherals, motor control application, induction motor and PMBDC motor control case studies.	7

	Textbooks
1	B. Widrow, S. D. Stearns, "*Adaptive Signal Processing*", Pearson Education, 2001.
2	Simon Haykin, "*Adaptive filter theory*", Pearson Education, 4th Edition, 2002.
3	B. Venkataramani, M. Bhaskar, "*Programming with DSPs*", Tata-McGraw-Hill publication, 2004.

	References
1	Texas Instruments DSP manuals-2407 and 6713 processors

	Useful Links
1	https://nptel.ac.in/courses/108/105/108105153
2	https://nptel.ac.in/courses/108/105/108105064
3	elearning.vtu.ac.in/, nptel.iitg.ernet.in/

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2				2		
CO3				3		

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Assessment

The assessment is based on MSE, ISE and ESE.
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Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7CS535
Course Name	Professional Elective 4: High Performance Electrical Drives
Desired Requisites:	Digital Signal Processing

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives

1	To provide fundamental knowledge in dynamics and control of Electric Drives.
2	To justify the selection of Drives for various applications.
3	To familiarize the various semiconductor controlled drives employing various motors.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	**Illustrate** different power electronic converter also identify about multi quadrant and hoist operation of electric drive	II	Understanding
CO2	**Analyze** and find the operation of half controlled and fully controlled operation of dc drives, also build the speed torque characteristics of dc drive.	IV	Analyzing
CO3	Illustrate, identify, recall of different chopper fed dc drives also **analyze** the different inverter fed ac drives.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Dynamics of Electrical Drives** Steady state load Torque speed characteristics, Multi quadrant operation of drives, Types of Braking-(a) Plugging, (b) dynamic/rheostat braking and (c) Regenerative braking. Starters- Typical control circuits for shunt and series motors, Three phase squirrel cage and slip ring induction motors	5
II	**DC Drives** Speed control of DC series and shunt motors – armature and field control, Solid state speed control of single phase and 3 phase DC drives with the following: Half wave converter and Semi converter, Solid state speed control of separately excited shunt and series motor drives	7
III	**AC Drives - Three Phase Induction Motor Drive** Basic principle of 3 phase induction motor drive. Solid state control of 3 phase induction motor: i. Stator voltage control -3 phase AC voltage controller and soft start. ii. Stator variable frequency control voltage source inverter- PWM drives and current source inverter drives, cycloconverter fed IM-drive. iii. Stator voltage and frequency control - Basics of V/f drive, scalar and vector or field oriented control of drives, V/f sensor less flux control drive. iv. Static rotor resistance control v. Slip power control – Static Kramer and Static Scherbius drive.	7
IV	**AC Drives - Three Phase Synchronous Motor Drive** Control of synchronous motor - Synchronous mode and Self mode. Self-controlled synchronous motor drive employing load commutated thyristor inverter, closed loop control Self-controlled synchronous motor drive employing cycloconverter	6

V	**Drives for Advanced Electrical Machines** Drive for brushless DC motor, Stepper motor drive, Drive for switched reluctance motor solar powered pump drive, DC drives with chopper control for electrical vehicle, Induction motor drive with voltage source inverter control for electrical vehicle.	7
VI	**Synchronous motor and SRM Drives** VSI fed synchronous motor drives, true synchronous and self-control mode, open loop and closed loop speed control of Permanent magnet synchronous machine, brushless DC motor drives. Switched reluctance motor drives, torque equation, converter circuits, operating modes and applications. Solar panel VI characteristics, solar powered pump,maximum power point tracking and battery-operated vehicles.	7

	Textbooks
1	B. Widrow, S. D. Stearns, "*Adaptive Signal Processing*", Pearson Education, 2001.
2	Simon Haykin, "*Adaptive filter theory*", Pearson Education, 4th Edition, 2002.
3	B.Venkataramani, M.Bhaskar, *"Programming with DSPs"*, Tata-McGraw-Hill publication, 2004.
	References
1	Texas Instruments DSP manuals-2407 and 6713 processors
	Useful Links
1	https://nptel.ac.in/courses/108/105/108105153
2	https://nptel.ac.in/courses/108/105/108105064
3	elearning.vtu.ac.in/, nptel.iitg.ernet.in/

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			1			
CO2				1		
CO3				2		1

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Each CO of the course must map to atleast one PO.

Assessment

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Semester- II
Open Elective (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7OE506
Course Name	Open Elective I: Control Techniques for Electrical Drives
Desired Requisites:	Modern Power Electronics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives

1	To provide the latest knowledge in the field of electrical drives.
2	To provide sufficient knowledge in the area of advanced control techniques for induction motor and synchronous machines.
3	To make the student aware of the research in the field of electrical drives.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO	Course Outcome Statement/s	Bloom's Taxonomy Level	Bloom's Taxonomy Description
CO1	**Explain** various concept used in AC and DC drives.	III	Applying
CO2	**Apply** control techniques to AC and DC drives.	III	Applying
CO3	**Analyze** control techniques for AC and DC drives.	IV	Analyzing
CO4	**Evaluate** various control schemes of AC and DC drives.	V	Evaluate

Module	Module Contents	Hours
I	**Basics of drives** Types & parts of the Electrical drives, fundamental torque equation, speed torques characteristics DC motor & Induction motor, multi quadrant operation of the drive, classification of mechanical load torques, steady state stability of the drive, constant torque and constant HP operation of the drive, closed loop speed control.	5
II	**DC motor drives** Methods of speed control, starting and breaking operation, single phase and three phase full controlled and half controlled converter fed DC drives, Multi quadrant operation of separately excited DC shunt motor, dual converter fed DC drives, circulating and non – circulating mode of operation, chopper control of DC shunt motor drives, four quadrant operation of chopper fed DC shunt motor drive.	7
III	**Induction motor drives** Speed control methods for three phase induction motor, VSI fed induction motor drive, constant torque (constant E/F and constant V/F), constant HP operation, closed loop speed control block diagram., CSI fed induction motor drive, speed torque characteristics of CSI fed drive, closed loop speed control block diagram, comparison of CSI fed and VSI fed induction motor drive, Stator voltage control. Chopper controlled resistance in rotor circuit, slip power recovery using converter cascade in rotor circuit, sub synchronous and super synchronous speed control, Kramer speed control.	7

IV	**Modeling of Induction Motor and PWM Techniques** abc – dq transformation, transformation from stationary reference frame to synchronously rotating reference frame and vice versa. Equivalent circuits of induction motor in dynamic dq stationary and synchronously rotating reference frame. Permanent magnet synchronous machine dq equivalent circuits. The three phase six step bridge inverter, three phase PWM inverter, PWM techniques such as sinusoidal PWM, hysteresis band current control PWM.	6
V	**Vector Control and Direct Torque Control of Induction Motor** Vector control of induction motor, DC drive analogy, equivalent circuit, phasor diagram. Direct rotor flux oriented vector control and indirect rotor flux oriented vector control, stator flux oriented vector control. Torque equation of IM in terms of stator and rotor flux, direct torque and flux control method (DTC) and self-commissioning of the drive.	7
VI	**Synchronous motor and SRM Drives** VSI fed synchronous motor drives, true synchronous and self-control mode, open loop and closed loop speed control of Permanent magnet synchronous machine, brushless DC motor drives. Switched reluctance motor drives, torque equation, converter circuits, operating modes and applications. Solar panel VI characteristics, solar powered pump, maximum power point tracking and battery operated vehicles.	7

	Textbooks
1	G. K. Dubey, *"Fundamentals of Electrical Drives"*, Narosa publication, 2nd edition, 2002.
2	B. K. Bose, *"Modern Power Electronics and AC drives"*, Prentice Hall of India Pvt. India, 1986.
3	
	References
1	Peter Vas, *"Vector Control of AC machines"*, Clarendon Press Oxford, 1999.
2	Ned Mohan, *"Advanced Electrical drives – Analysis, control and modeling using Simulink"*, John Wiley and sons, 2001.
3	P. S. Bhimra, *"Power Electronics"*, 2nd edition, Khanna Publishers.
	Useful Links
1	NPTEL video lectures on Electrical Drives

CO-PO Mapping

	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				1		
CO2				1		
CO3			1	2		1
CO4			1	3		

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