Walchand College of Engineering

(Government Aided Autonomous Institute)

Vishrambag, Sangli. 416415

Course Contents for

F.Y. M.Tech. (Control System Engineering)

Sem I and II

2022-23

Semester - I
Professional Core (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS501
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	This course provides the basics of modelling of the physical system, analysis.
2	It provides the methodology of designing the controller with realization.
3	It gives 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	**Analyze** various controller structures	IV	Analyze
CO2	**Evaluate** controller performance using various control algorithms.	V	Evaluate
CO3	**Design** a controller to meet given performance specification.	VI	Create

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.	6
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.	6
III	**PID Controller** Introduction, sampling, discretization techniques, PID controller, methods of tuning, 2-DOF controller with integral action, bump less PID controller, PID with filtering, 2-DOF PID, systems with delay.	6
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 Controllers** T**hrough 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 for unstable plant, LQR through pole placement.	6

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.	6
Textbooks		
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 AntoniVisioli Else vier publication 2nd Edition 2013.	
2	*"Discrete Time Control System"* By Katsuhiko Ogata, Pearson Education 2nd Edition 2005.	
Useful Links		
1	http://nptel.ac.in/downloads/117105077	
2	http://www.nptelvideos.in/2012/12/digital-communication.html	
3	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-450-principles-of-digital-communications-i-fall-2006/video-lectures/	

CO-PO Mapping						
	Programme Outcomes (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2			2			
CO3				3		
CO4						

The strength of mapping is to be written as 1,2,3; 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)

Walchand College of Engineering, Sangli

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AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS502
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	This course provides the basics of process control.
2	It provides the methodology of modelling the process and close loop control.
3	It also provides the design of various types of controllers for single loop and multi loop control system.
4	It gives 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	Apply
CO2	**Analyze** the problems associated with open loop and close loop process control system.	IV	Analyze
CO3	**Evaluate** the performance of processes with various conventional and advanced controllers.	V	Evaluate
CO4	**Design** various conventional and advanced controllers for the processes.	VI	Create

Module	**Module Contents**	**Hours**
I	**Introduction to Process Control** Introduction, Design aspects of a process control system, Hardware for a process control system. Mathematical modelling and analysis of processes, development of a mathematical model, Modelling considerations for control purposes, the input-output model, degree of freedom.	5
II	**Modelling of Process** Computer Simulation and linearization of nonlinear systems, Transfer functions and the Input-output models. Dynamic behaviour of first-order systems, second-order system and higher order systems.	5
III	**Feedback Control of Process** Elements of feedback control system, types of feedback controllers, sensors, Transmission lines, final control elements. Dynamic behaviour of feedback-controlled process, Effect of proportional (p) control, Integral (I) control and derivative (D) control on the response of controlled process, effect of composite control actions.	6

IV	**Multi Loop Control** Feedback control of system with large dead time or inverse response, processes with large Dead time, Dead time compensation, and control of systems with inverse response. Control systems with multiple loops, cascade control, split-range control, feed forward control, Ratio-control, problem in designing feed forward controllers, practical aspects on the design of feed forward controllers, F/F – F/B control.	7
V	**MIMO Process** Multi-input, multi-output processes, degree of freedom and number of controlled and Manipulated variables, interaction and decoupling of control loops, relative gain array and selection of loops, design of non-interacting control loops. Overview of modern control methodologies: PLC, SCADA, DCS, Adaptive control, variable structure control.	7
VI	**Centralized Multivariable Control** Multivariable model predictive control, single-variable dynamic matrix control (DMC) algorithm, multivariable dynamic matrix control, internal model control, smith predictive, model predictive control, process model-based control, implementation guidelines. Process control design: sequence of design steps, statistical process control.	6

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, Mc Graw 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	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-ch10/
2	https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-ge01/

CO-PO Mapping						
	Programme Outcomes (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			1			
CO2			1			
CO3				2		
CO4				2		1

The strength of mapping is to be written as 1,2,3; 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)

Professional Core (Lab) Courses

Walchand College of Engineering, Sangli

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AY 2022-23

Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M.Tech., Sem I
Course Code	6CS547
Course Name	Research Methodology for Control System Engineers
Desired Requisites:	

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

Course Objectives

1	To develop a research orientation among the students and to acquaint them with fundamentals of research methods.
2	To develop understanding of the basic framework of research process and techniques
3	To identify various sources of information for literature review and data collection.
4	To develop an understanding of the ethical dimensions of conducting applied research.
5	To develop understanding about patent process.

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** various methods to solve research problem.	III	Apply
CO2	**Construct** a research problem in respective engineering domain.	III	Apply
CO3	**Investigate** various data analysis techniques for a research problem.	IV	Analyze
CO4	**Identify** various Intellectual Property Rights procedures	III	Apply

List of Experiments / Lab Activities/Topics

List of Topics:

I. Research Fundamentals

What is research, types of research, the process of research, Literature survey and review, Formulation of a research problem.

II. Research Methods

Research design- Meaning, Need and Types, Research Design Process, Measurement and scaling techniques, Data Collection – concept, types and methods, Processing and analysis of data, Design of Experiment

III. Analysis Techniques

Quantitative Techniques, sampling fundamentals, testing of hypothesis using various tests like Multivariate analysis, Use of standard statistical software, Data processing, Preliminary data analysis and interpretation, Uni-variate and bi-variate analysis of data, testing of hypotheses.

IV. Research Communication

Writing a conference paper, Journal Paper, Technical report, dissertation/thesis writing. Presentation techniques, software used for report writing such as WORD, Latex etc. Types of journal/conference papers

V. Intellectual Property Rights

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

VI. Patents and Patenting Procedures

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

Textbooks	
1	C. R. Kothari, "*Research Methodology*", New Age international
2	Deepak Chopra and Neena Sondhi, "*Research Methodology : Concepts and cases*", Vikas Publishing House, New Delhi

References	
1	E. Philip and Derek Pugh, How to get a Ph. D. – a handbook for students and their supervisors, open university press
2	Stuart Melville and Wayne Goddard, *" Research Methodology: An Introduction for Science & Engineering Students"*

Useful Links	
1	NPTEL Lectures

CO-PO Mapping

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

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

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AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS545
Course Name	Applied Digital Control Laboratory
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	This course provides the basics of modelling of the physical system, analysis
2	It provides the methodology of designing the controller with realization
3	It gives 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	**Analyze** various types of digital controllers	IV	Analyzing
CO2	**Experiment** on closed loop systems using controllers	III	Apply
CO3	**Design** pole placement controllers for various electrical systems	VI	Creating

List of Experiments / Lab Activities/Topics

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

Textbooks	
1	Kannan M. Moudgalya, "*Digital Control*", Wiley, 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	Torkel Glaw and Lennard Ljung, " *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	-

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

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS546
Course Name	Advanced Process Control Laboratory
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	Understand
CO2	**Apply** the tuning techniques for various controllers.	III	Apply
CO3	**Evaluate** the performance of given Process Control system.	V	Evaluate
CO4	**Demonstrate** the use of advanced controllers.	III	Apply

List of Experiments / Lab Activities/Topics

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

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, Mc Graw 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	http://vlabs.iitkgp.ernet.in/cpd/index.html#

2	http://vlabs.iitb.ac.in/vlab/maglev/index.html#

CO-PO Mapping

Programme Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1			
CO2				1		
CO3				2		
CO4						2

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least 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 2022-23

Course Information

Programme	M. Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS551
Course Name	Presentation and Technical Report Writing
Desired Requisites:	MS Office

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

Course Objectives

1	To provide an opportunity to student to do work independently on a topic.
2	To encourage creative thinking process in technical report writing

3	To enable student for good technical report writing and effective presentations.

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 characteristics of technical and business writing.	III	Apply
CO2	**Produce** documents related to technology and writing in the workplace and will have improved their ability to write clearly, concisely, and accurately.	VI	Create
CO3	**Use** a variety of materials to produce appropriate visual presentation for documents, such as instructions, descriptions, and research reports.	V	Evaluate

List of Experiments / Lab Activities/Topics

This course introduces students to the discipline of technical communication. Preparation of visuals to supplement text, workplace communication, descriptions of mechanisms, explanations of processes, and writing reports are the major topics included.
This course is designed for students enrolled in technical degree programs for making them industry ready.

Textbooks

1	Suitable books based on the contents of the topic.

References

1	Suitable books based on the contents of the selected topic and research papers from reputed national and international journals and conferences.

Useful Links

1	As per the need of the topic of report and presentation

CO-PO Mapping

Programme Outcomes (PO)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3				
CO2		2		1		
CO3		1				2

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least 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 2022-23

Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS552
Course Name	Professional Skills 1
Desired Requisites:	-

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

Course Objectives

1	To provide a hands-on experience of software in solving complex Electrical engineering problems.
2	To enhance the employability of Electrical engineering student.

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	**Use** of the software related to Electrical engineering effectively.	V	Evaluate
CO2	**Develop** skills related to employment for Electrical engineering students.	VI	Create
CO3	**Explain** the process of problem-solving using computing tools.	II	Understand

List of Experiments / Lab Activities/Topics

This course is based on computing as a tool to design and analyse the Electrical system. In the modern day work environment, the Electrical engineers should be able to simulate and solve complex problems on computers. The Electrical engineer must be highly computer literate. The engineer with strong fundamentals in Electrical Engineering and computer software proficiency is highly in demand from industry. Employability of the student can be enhanced by providing software training in Electrical engineering, Aptitude and reasoning practice sessions, interpersonal skill improvement activities etc.

Textbooks

1	Suitable books based on the software selected.

References

1	Suitable books based on the contents of software selected

Useful Links

1	As per the need of the software training

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

Professional Elective (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS511
Course Name	Professional Elective 1: 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	This course provides the basic concepts of optimal control
2	It provides the methodology of designing LQR and LQT optimal control
3	It gives 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.	8
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.	6
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	6
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	D.S.Naidu, '*Optimal Control Systems'*, CRC Press, 2002.

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

Useful Links	
1	-

CO-PO Mapping						
Programme Outcomes (PO)						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2				2		
CO3						1

The strength of mapping is to be written as 1,2,3; 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)

Walchand College of Engineering, Sangli

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS512
Course Name	Professional Elective-1: 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	Understand
CO2	**Apply** system identification for predicting dynamic models.	III	Apply
CO3	**Analyze** models obtained from system identification.	IV	Analyze

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.	4
II	**Random Processes** Random variables, Covariance and Correlation, Auto-Correlation and Cross-Correlation functions, Moving Average models, Auto-Regressive models, ARMA models, Spectral representations.	6
III	**Estimation Theory** Introduction to Estimation, Properties of estimator, Estimation methods, Estimation of Signal Properties.	6
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.	7
V	**Input-Output Identifications** Estimation of Time-Series Models, Estimation of Impulse/Step (Response) Models, Estimation of Frequency Response Functions, Estimation of Parametric Input-Output Models.	7
VI	**Sub-space Identification** State Space model for identification, Kalman filter, Innovations form, Sub-space identification algorithm, Estimating grey-box models.	6

Textbooks

1	Arun K Tangirala, "*Principles of System Identification Theory and Practice*", CRC Press, 2015.
2	Sodderstrom & Stoica, "*System Identification*",PHI,1989

References

1	Ljung L, Glad T, "*Modeling of Dynamic Systems*", PHI, 1994
Useful Links	
1	-

CO-PO Mapping						
Programme Outcomes (PO)						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				2		
CO2						1
CO3				3		
The strength of mapping is to be written as 1,2,3; 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)

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AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS513
Course Name	Professional Elective 2: Multivariable Control
Desired Requisites:	Control System

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 Multivariable Control.
2	It provides the methodology of designing Multivariable Control.
3	It gives 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	Analyze
CO3	**Evaluate** algorithms for centralized, decentralized and decoupled control in multivariable control system.	V	Evaluate

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.	6
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.	6
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.	6
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.	6
VI	**Centralized closed loop control** State feedback, output feedback, rejection of deterministic, unmeasurable disturbance, Augmented plant, process and disturbance models, case study – magnetic suspension.	6

Textbooks	
1	P.Albertos, A.Sala, *"Multivariable Control",* springer Int. 2008.
2	Z. Bubnicki, *"Multivariable Control",* springer Int. 2005.
3	B. WayneBeguetle, *"Modelling with Control",* PHI 2008.

References	
1	Gopal, "*Modern Control System -State variable analyses"*, TMH Publications, 2010.

Useful Links	
1	-

CO-PO Mapping						
	Programme Outcomes (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2				2		
CO3						1

The strength of mapping is to be written as 1,2,3; 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)

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AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6CS514
Course Name	Professional Elective 2: Advanced Digital Signal Processing
Desired Requisites:	

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 skills for analysing 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	Apply
CO2	**Analyze** the properties of discrete time systems and random signals processing.	IV	Analyze
CO3	**Evaluate** digital filters, structures and discrete time random signals.	V	Evaluate

Module	**Module Contents**	**Hours**
I	**Discrete Time Signal and System** Classification of signals, operation on sequences, properties of systems, convolution sum, sampling process.	4
II	**Discrete Time Fourier Transform** DFT, FFT, DIT FFT, DIF FFT algorithm, circular convolution.	6

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.	8
IV	**Digital Filter Design** Butter worth and chebyshev filters, IIR filter design, impulse invariant method, bilinear transformation, FIR filter design.	7
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.	5

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

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

Useful Links	
1	-

CO-PO Mapping						
Programme Outcomes (PO)						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				2		
CO2				2		
CO3			1	2		
CO4						

The strength of mapping is to be written as 1,2,3; 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

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AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6CS521
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 behaviour 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	Apply
CO2	**Examine** behaviour of nonlinear systems through various mathematical tools.	IV	Analyze
CO3	**Recommend** step by step approach for investigating the dynamics of nonlinear systems.	V	Evaluate

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.	6
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	5
IV	**Periodic Orbits** Bendixson criterion and Poincare-Bendixson criterion, Lotka predator prey model, van-der-Pol oscillator, Linearization.	6
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.	8

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.	6

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 (PO)						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2				3		
CO3						2
CO4						

The strength of mapping is to be written as 1,2,3; 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)

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6CS522
Course Name	PLC and Embedded Control
Desired Requisites:	Instrumentation Techniques, Electrical Measurements, 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	IV	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	6
II	**PLC programming** PLC timer functions, Types of PLC timers, Programming of Non-retentive timers for various applications, Programming of ON timers, OFF timers, PLC counter functions, Programming of UP, DOWN counters, Case studies related to Industrial Automations	6
III	**PLC Timer and Counter Functions** PLC timer functions, Types of PLC timers, Programming of Non-retentive timers for various applications, Programming of ON timers, OFF timers, PLC counter functions, Programming of UP, DOWN counters, Case studies related to Industrial Automations	6
IV	**PLC Arithmetic, Comparison and Branch functions** PLC Arithmetic functions, PLC comparison functions, Conversion functions, Master control relay functions, PLC jump functions, Jump with return and Jump with No return functions, Programs related to Arithmetic, Comparison and Branch functions	6
V	**Advanced PLC functions** Data move system, data handling functions, Digital bit functions and applications, sequencer functions Analog PLC operations, PID control of continuous process, PID modules & tuning, typical PID functions	6
VI	**PLC Networking** Networking of PLCs, Levels of Industrial Control, Types of Networking, Network Communications, Cell control by PLC Networks, Factors to consider in selecting a PLC	6

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	Gary dunning, "*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 (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2				3		
CO3				2		
CO4						

The strength of mapping is to be written as 1,2,3; 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)

Professional Core (Lab) Courses

Walchand College of Engineering, Sangli

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AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6CS591
Course Name	Non-Linear Dynamical Systems Laboratory
Desired Requisites:	

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	Apply
CO2	**Analyze** the stability of nonlinear system using programming and simulation tools.	IV	Analyze
CO3	**Evaluate** the behaviour of periodic orbit using programming and simulation tools.	V	Evaluate

List of Experiments / Lab Activities/Topics

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.

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

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High

Each CO of the course must map to at least 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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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6CS592
Course Name	PLC and Embedded Control Laboratory
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

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.

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	Gary dunning, "*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 (PO)					
	1	2	3	4	5	6
CO1			2			
CO2				2		
CO3				2		

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High

Each CO of the course must map to at least 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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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6CS593
Course Name	Pre-dissertation Work and Seminar
Desired Requisites:	-

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	4 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction		30	30	40	100
		Credits: 2			

Course Objectives

1	This course is aimed at developing the skills like literature review, identification and analysis of issues in societal context in general and electrical control systems in particular.
2	This course shall provide an opportunity to the student to develop self-learning, critical thinking and communication skill.

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	**Summarize** the basics concepts used in research paper.	II	Understanding
CO2	**Outline** the important contributions and the impact of proposed solutions on electrical control systems.	V,II	Evaluating Understanding
CO3	**Examine** different contributions in electrical control systems engineering and **identify** promising directions in the societal context.	III, IV	Applying Analyzing
CO4	**Analyze** and **evaluate** research papers critically and efficiently.	IV, V	Analyzing Evaluating

List of Experiments / Lab Activities/Topics

Pre-Dissertation Seminar shall be delivered on one of the advanced topics chosen in control systems after compiling the information from the latest literature and also internet. The concepts must be clearly understood and presented by the student. All modern methods of presentation should be used by the student. A hard copy of the report (25 to 30 pages A4 size, 12 fonts, Times New Roman, single spacing both side printed, preferably in IEEE format) should be submitted. A PDF copy of the report in soft form must also be submitted with other details if any.

Textbooks	
1	As per topic Selected and Journal papers, Conference papers, Handbooks.
References	
1	As per topic Selected and Journal papers, Conference papers, Handbooks.
Useful Links	
1	-

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	2					
CO2		2	2		2	
CO3					3	2
CO4				3		2
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High Each CO of the course must map to at least 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.				

Professional Elective (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M.Tech., Sem II
Course Code	6CS531
Course Name	Professional Elective 3: Neural Network and Fuzzy 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	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.	6
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.	6
III	**Unsupervised Learning Networks** Associative learning- simple associative learning, Unsupervised Hebb, Modifications in Hebb, Instar and out star rule, Application to control.	6
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.	6
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.	6

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			3			
CO2				2		
CO3				2		

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High

Each CO of the course must map to at least one PO.

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

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 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6CS532
Course Name	Professional Elective 3: 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.
4	It provides the basics of embedded processors for DSP applications.

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.	6
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.	6
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.	6
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	6
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.	6

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	-

CO-PO Mapping
Programme Outcomes (PO)

	1	2	3	4	5	6
CO1				3		
CO2				2		
CO3				3		

The strength of mapping is to be written as 1,2,3; 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)

Professional Elective (Lab) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6CS571
Course Name	Professional Elective 3 Laboratory: Neural Network and Fuzzy Control Laboratory
Desired Requisites:	Engineering Mathematics

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

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	**Demonstrate** the Neural Networks and Fuzzy Control techniques.	III	Applying
CO2	**Analyze** different Neural Networks and Fuzzy Control	IV	Analyzing
CO3	**Evaluate** different Neural Networks and Fuzzy Control	V	Evaluating

List of Experiments / Lab Activities/Topics

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.

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 (PO)

	1	2	3	4	5	6
CO1	1			3		
CO2	1			3		

CO3	1			3		

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High

Each CO of the course must map to at least 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 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6CS572
Course Name	Professional Elective 3 Laboratory: Modern Signal Processing Laboratory
Desired Requisites:	Digital Signal Processing

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

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.
4	It provides the basics of embedded processors for DSP applications.

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 least square algorithms to adaptive signal processing.	III	Applying
CO2	**Analyze** adaptive and kalman filter.	IV	Analyzing
CO3	**Experiment** with Embedded processors for DSP applications.	IV	Analyzing

List of Experiments / Lab Activities/Topics
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.

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	-

CO-PO Mapping

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

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High

Each CO of the course must map to at least 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.

Open Elective Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6OE506
Course Name	Open Elective : Control Techniques for Electrical Drives
Desired Requisites:	M.Tech. (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 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.	II	Understand
CO2	**Apply** control techniques to AC and DC drives.	III	Apply
CO3	**Analyze** control techniques for AC and DC drives.	IV	Analyze
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.	6
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.	5
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.	6

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.	6
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.	6

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.
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 (PO)						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				1		
CO2				1		
CO3			1	2		
CO4			1	3		

The strength of mapping is to be written as 1,2,3; 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)