Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2021-22

Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS501
Course Name	Applied Digital Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives

1	This course provides the basics of modeling 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,

CO1	**Analyze** various controller structures	Analyze
CO2	**Evaluate** controller performance using various control algorithms.	Evaluate
CO3	**Design** a controller to meet given performance specification.	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, bumpless PID controller, PID with filtering, 2-DOF PID, systems with delay.	6
IV	**Pole Placement Controllers**	6

	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.	
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 fo 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

Text Books	
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		

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 (for Theory Course)

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be 1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3, 4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level (Marks) For Theory Course					
Bloom's Taxonomy Level		**T1**	**T2**	**ESE**	**Total**
1	Remember				
2	Understand				
3	Apply				
4	Analyze	10		20	30
5	Evaluate	10	10	20	40
6	Create		10	20	30
Total		**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS502
Course Name	Advanced Process Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**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,		
CO1	**Calculate** the various models of industrial processes.	Apply
CO2	**Analyze** the problems associated with open loop and close loop process control system.	Analyze
CO3	**Evaluate** the performance of processes with various conventional and advanced controllers.	Evaluate
CO4	**Design** various conventional and advanced controllers for the processes.	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 modeling and analysis of processes, development of a mathematical model, Modeling 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 behavior 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,	6

	Transmission lines, final control elements. Dynamic behavior 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.	
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

Text Books	
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 (for Theory Course)
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be 1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3, 4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level (Marks) For Theory Course					
Bloom's Taxonomy Level		**T1**	**T2**	**ESE**	**Total**
1	Remember				
2	Understand				
3	Apply	10		10	20
4	Analyze	10		20	30
5	Evaluate		10	20	30
6	Create		10	10	20
Total		**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M.Tech., Sem I
Course Code	5CS560
Course Name	Research Methodology
Desired Requisites:	None

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	-				
Interaction	2 Hrs/week	**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,		
CO1	**Classify** various methods to solve research problem.	Apply
CO2	**Construct** a research problem in respective engineering domain.	Apply
CO3	**Investigate** various data analysis techniques for a research problem.	Analyze
CO4	**Identify** various Intellectual Property Rights procedures	Apply

Module	**Module Contents**	**Hours**
I	**Research Fundamentals** What is research, types of research, the process of research, Literature survey and review , Formulation of a research problem.	4
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	5
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.	5

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	4
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.	5
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	4

Text Books	
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. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	**Based on**	**Conducted by**	**Typical Schedule (for 26-week Sem)**	**Marks**
LA1	Lab activities, attendance	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. 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.				

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand				
Apply	20	20	20	**60**
Analyze	10	10	20	**40**
Evaluate				
Create				
Total Marks	**30**	**30**	**40**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS551
Course Name	Activity Based Lab for Applied Digital Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/Week				
Interaction	-	**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,

CO1	**Analyze** various types of digital controllers	Analyzing
CO2	**Experiment** on closed loop systems using controllers	Apply
CO3	**Design** pole placement controllers for various electrical systems	Creating

List of Experiments / Lab Activities

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

Text Books

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

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. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	**Based on**	**Conducted by**	**Typical Schedule (for 26-week Sem)**	**Marks**
LA1	Lab activities, attendance	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. 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.

	Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
	Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
	Remember				
	Understand				
	Apply	10	10	10	**30**
	Analyze	10	10	20	**40**
	Evaluate				
	Create	10	10	10	**30**
	Total Marks	**30**	**30**	**40**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS552
Course Name	Activity Based Lab for Advanced Process Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/Week				
Interaction	-	**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,

CO1	**Determine** the model of process by performing experiments on Process Control System.	Understand
CO2	**Apply** the tuning techniques for various controllers.	Apply
CO3	**Evaluate** the performance of given Process Control system.	Evaluate
CO4	**Demonstrate** the use of advanced controllers.	Apply

List of Experiments / Lab Activities

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

Text Books

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. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. 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.

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand	10	10	10	**30**
Apply	10	10	20	**40**
Analyze				
Evaluate	10	10	10	**30**
Create				
Total Marks	**30**	**30**	**40**	**100**

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Course Information	
Programme	M. Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS553
Course Name	Presentation and Technical Report Writing
Desired Requisites:	MS Office

Teaching Scheme (Hrs)		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	-				
Interaction	1	**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, students will be able to,		
CO1	**Demonstrate** the characteristics of technical and business writing.	Apply
CO2	**Produce** documents related to technology and writing in the workplace and will have improved their ability to write clearly, concisely, and accurately.	Create
CO3	**Use** a variety of materials to produce appropriate visual presentation for documents, such as instructions, descriptions, and research reports.	Evaluate

Course Content

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.

Text Books	
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. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	**Based on**	**Conducted by**	**Typical Schedule (for 26-week Sem)**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. 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.				

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze				
Evaluate	10	10	10	**30**
Create	10	10	20	**40**
Total Marks	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS554
Course Name	Professional Skills 1
Desired Requisites:	-

Teaching Scheme (Hrs)		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	-				
Interaction	1	**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, students will be able to,		
CO1	**Use** of the software related to Electrical engineering effectively.	Evaluate
CO2	**Develop** the solution for Electrical engineering problem using software.	Create
CO3	**Explain** the process of problem solving using computing tools.	Understand

Course Content

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.

Text Books	
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. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	**Based on**	**Conducted by**	**Typical Schedule (for 26-week Sem)**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. 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.				

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand	10	10	10	**30**
Apply				
Analyze				
Evaluate	10	10	15	**35**
Create	10	10	15	**35**
Total Marks	**30**	**30**	**40**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS511
Course Name	Professional Elective 1: Optimal Control
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**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,

CO1	**Apply** various concepts of optimal control.	Applying
CO2	**Analyze** the systems using LQR and LQT optimal control.	Analyzing
CO3	**Design** of optimal control in constrained and non-constrained systems.	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-	6

	Time Linear Quadratic Regulator: Time-Varying Case, Infinite-Time LQR System	
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

Text Books	
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 (for Theory Course)
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be 1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3, 4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level (Marks) For Theory Course					
Bloom's Taxonomy Level		**T1**	**T2**	**ESE**	**Total**
1	Remember				
2	Understand				
3	Apply	10		20	30
4	Analyze	10	10	20	40
5	Evaluate				
6	Create		10	20	30
Total		**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS512
Course Name	Professional Elective-1: System Identification
Desired Requisites:	Engineering Mathematics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**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,

CO1	**Explain** fundamental aspects of system identification.	Understand
CO2	**Apply** system identification for predicting dynamic models.	Apply
CO3	**Analyze** models obtained from system identification.	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

Text Books	
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)						
	1	2	3	4	5	6
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 (for Theory Course)
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be 1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3, 4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level (Marks) For Theory Course					
Bloom's Taxonomy Level		**T1**	**T2**	**ESE**	**Total**
1	Remember				
2	Understand	10		20	30
3	Apply	10	10	20	40
4	Analyze		10	20	30
5	Evaluate				
6	Create				
Total		**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS513
Course Name	Professional Elective 2: Multivariable Control
Desired Requisites:	Control System

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**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,

CO1	**Interpret** the basic concepts of Multivariable Control.	Applying
CO2	**Analyze** the centralized, decentralized and decoupled control in multivariable control system	Analyze
CO3	**Evaluate** algorithms for centralized, decentralized and decoupled control in multivariable control system.	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

Text Books	
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.

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 (for Theory Course)
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be 1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3, 4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level (Marks) For Theory Course					
Bloom's Taxonomy Level		**T1**	**T2**	**ESE**	**Total**
1	Remember				
2	Understand				
3	Apply	10		20	30
4	Analyze	10	10	20	40
5	Evaluate		10	20	30
6	Create				
Total		**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5CS514
Course Name	Professional Elective 2: Advanced Digital Signal Processing
Desired Requisites:	Digital Signal Processing

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**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,

CO1	**Apply** transforms to discrete time signals for analysis.	Apply
CO2	**Analyze** the properties of discrete time systems and random signals processing.	Analyze
CO3	**Evaluate** digital filters, structures and discrete time random signals.	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

Text Books	
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.

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1				2		
CO2				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 (for Theory Course)
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be 1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3, 4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level (Marks) For Theory Course					
Bloom's Taxonomy Level		**T1**	**T2**	**ESE**	**Total**
1	Remember				
2	Understand				
3	Apply	10		20	30
4	Analyze	10	10	20	40
5	Evaluate		10	20	30
6	Create				
Total		**20**	**20**	**60**	**100**

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Course Information

Programme	M. Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	5IC501
Course Name	Constitution of India
Desired Requisites:	

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: Nil**			

Course Objectives

1	To review and create awareness on various provisions in the constitution of India.

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO1	**Explain** the premises informing the twin themes of liberty and freedom from a civil rights perspective.	Understanding
CO2	**Address** the growth of Indian opinion regarding modern Indian intellectuals constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism	Understanding
CO3	**Address** the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution	Understanding

Module	**Module Contents**	**Hours**
I	History of Making of the Indian Constitution Drafting Committee, (Composition & Working	4
II	**Philosophy of the Indian Constitution :** Preamble, Salient Feature	4
III	**Contours of Constitutional Rights:** Fundamental Rights; Right to Equality; Right to Freedom; Right against Exploitation; Right to Freedom of Religion; Cultural and Educational Rights; Right to Constitutional Remedies; Directive Principles of State Policy; Fundamental Duties.	5
IV	**Organs of Governance:** Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions	5

V	**Local Administration:** District"s Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy	5
VI	**Election Commission:** Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.	5

Text Books	
1	Dr. S. N. Busi, Dr. B. R. Ambedkar "*Framing of Indian Constitution*", 1st Edition, 2015.
2	M. P. Jain, "*Indian Constitution Law"*, 7th Edn., Lexis Nexis, 2014
3	D.D. Basu, "*Introduction to the Constitution of India"*, Lexis Nexis, 2015
References	
1	The Constitution of India, 1950 (Bare Act), Government Publication
Useful Links	
1	https://en.wikipedia.org/wiki/Constituent_Assembly_of_India
2	https://nptel.ac.in/courses/129/106/129106003/
3	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-lw02/
4	https://eci.gov.in/about/about-eci/the-functions-electoral-system-of-india-r2/

CO-PO Mapping

	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1			1			
CO2	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 (for Theory Course)

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level (Marks) For Theory Course					
Bloom's Taxonomy Level		**T1**	**T2**	**ESE**	**Total**
1	Remember				
2	Understand	20	20	60	100
3	Apply				
4	Analyze				
5	Evaluate				
6	Create				
Total		**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS521
Course Name	Non-Linear Dynamical Systems
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**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,		
CO1	**Classify** features of nonlinear systems.	Apply
CO2	**Examine** behaviour of nonlinear systems through various mathematical tools.	Analyze
CO3	**Recommend** step by step approach for investigating the dynamics of nonlinear systems.	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

Text Books	
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.

Assessment

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	20	**40**
Analyze	10	10	20	**40**
Evaluate			20	**20**
Create				
Total	**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS522
Course Name	PLC and Embedded Control
Desired Requisites:	Instrumentation Techniques, Electrical Measurements, Microcontroller and Applications

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**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,

CO1	**Interpret** features of PLC and Embedded Control Systems used for Industrial Automation.	Applying
CO2	**Use** ladder logic programming technique for various PLC applications.	Applying
CO3	**Evaluate** the performance of PLC network configurations, PLC functions used for different application	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

Text Books	
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				3		
CO2				3		
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
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	20	10	30	**60**
Analyze				
Evaluate		10	30	**40**
Create				
Total	**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS571
Course Name	Activity Based Lab for Non-Linear Dynamical Systems
Desired Requisites:	Control System Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**Lab ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/Week				
Interaction	-	**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,

CO1	**Demonstrate** the properties of nonlinear systems using simulation.	Apply
CO2	**Analyze** the stability of nonlinear system using programming and simulation tools.	Analyze
CO3	**Evaluate** the behavior of periodic orbit using programming and simulation tools.	Evaluate

List of Experiments / 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.

Text Books

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. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	**Based on**	**Conducted by**	**Typical Schedule (for 26-week Sem)**	**Marks**
LA1	Lab activities, attendance	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab

activities/Lab performance shall include mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand				
Apply	20	10	10	**40**
Analyze	10	10	10	**30**
Evaluate		10	20	**30**
Create				
Total Marks	**30**	**30**	**40**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS572
Course Name	Activity Based Lab for PLC and Embedded Control
Desired Requisites:	Instrumentation Techniques, Electrical Measurements Lab, Microcontroller and Applications Lab

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**Lab ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/Week				
Interaction	-	**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,

CO1	**Execute** experiments based on PLC systems.	Applying
CO2	**Construct** basic control systems using PLCs.	Analyzing
CO3	**Design** ladder logic programs for various PLC applications.	Creating

List of Experiments / 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.

Text Books

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. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	**Based on**	**Conducted by**	**Typical Schedule (for 26-week Sem)**	**Marks**
LA1	Lab activities, attendance	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab

activities/Lab performance shall include mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	10	10	10	**30**
Evaluate				
Create	10	10	20	**40**
Total Marks	**30**	**30**	**40**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS573
Course Name	Industrial Project
Desired Requisites:	

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical					
Interaction	2 Hr/Week	**Credits: 2**			

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,

CO1	**Chose, Formulate** a clear problem.	Apply
CO2	**Select and apply** appropriate engineering methods and tools for solving the problem.	Create
CO3	**Develop** the project and its results following an established project methodology.	Evaluate
CO4	**Present** the project results.	Analyze

List of Experiments / Lab Activities

Industrial Project:

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.

Text Books	
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 (PO)						
	1	2	3	4	5	6
CO1	3	2				
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. LA1, LA2 together is treated as In-Semester Evaluation

Assessment	Based on	Conducted by	Typical Schedule	Marks
LA1	Lab activities, attendance	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. 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.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand				
Apply	30	10	5	**45**
Analyze		10	5	**15**
Evaluate		10	10	**20**
Create			20	**20**
Total	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS574
Course Name	Professional Skills 2
Desired Requisites:	

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	-				
Interaction	1 Hr/Week	**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, students will be able to,		
CO1	**Use** of the software related to Electrical Engineering effectively.	Evaluate
CO2	**Develop** the solution for Electrical Engineering problem using software.	Create
CO3	**Explain** the process of problem-solving using computing tools.	Understand

Course Content

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

Text Books	
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)					
	1	**2**	**3**	**4**	**5**	**6**
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. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. 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.

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand	10	10	10	**30**
Apply				
Analyze				
Evaluate	10	10	15	**35**
Create	10	10	15	**35**
Total Marks	**30**	**30**	**40**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS523
Course Name	Professional Elective 3: Adaptive Control
Desired Requisites:	Applied Digital Control

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

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,

CO1	**Analyze** modern and adaptive control techniques for controller design	Analyze
CO2	**Evaluate** various adaptive control algorithms.	Evaluate
CO3	**Design** various adaptive controllers like MRAC, STR and LQG.	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	5

	minimum variance controller, ARMAX and ARIMAX model, PID tuning through GMVC control.	
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.	5
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.	5
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.	4
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.	4

Text Books	
1	Kannan M. Moudgalya, "*Digital Control*", TMH publications, 2007.
References	
1	Astrom, Wittenmark, "*Adaptive Control*", Pearson Education, 1995.
2	PetrosIoannous, 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 (PO)						
	1	2	3	4	5	6
CO1				3		
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
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply				
Analyze	10	5	20	**35**
Evaluate	10	5	20	**35**
Create		10	20	**30**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS524
Course Name	Professional Elective 3: Computational Methods
Desired Requisites:	Engineering Mathematics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	The course is designed to provide a view of using various computational techniques and tools for analysis, decision making and solution of engineering problems.
2	It provides methodology to learn how to numerically integrate continuous and discrete functions, solve nonlinear equations, cure fitting etc.
3	It will give overview of how to solve ordinary differential equations with initial value or boundary value problems.

Course Outcomes (CO) with Bloom's Taxonomy Level		
At the end of the course, the students will be able to,		
CO1	**Understand** the concept and steps of problem solving - mathematical modelling, solution and implementation.	Understanding
CO2	**Use** of knowledge and understanding of mathematical techniques to solve mathematical problems.	Applying
CO3	**Apply** mathematical reasoning in several different areas of mathematics.	Applying

Module	**Module Contents**	**Hours**
I	**Introduction** Motivation and applications, Computation and Error Analysis: Accuracy and precision, Truncation and round-off errors, Binary Number System, Error propagation.	5
II	**Algebraic Equations** Formulation and solution of linear system of equations, Gauss elimination, LU, QR decomposition, Iteration methods (Gauss-Seidal),	5

	convergence of iteration methods, Singular value decomposition and the sensitivity of rank to small perturbation	
III	**Interpolation & Regression Methods** Newton‘s divided difference, interpolation polynomials, Lagrange interpolation polynomials, Linear and non-linear regression, multiple linear regression, general linear least squares	5
IV	**Transform Techniques** Vector spaces, Basis vectors, Orthogonal/Unitary transform, Fourier transform, Laplace transform	5
V	**Optimization Techniques for Engineers** Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function	4
VI	**Graph Theory** Graphs and Matrices, simple graph, cyclic graph, complete graph, properties of the Laplacian matrix and relation with graph connectivity. Non-negative matrices. Applications of graph theory to engineering problems	4

Text Books	
1	Steven C. Chapra and Raymond P. Canale , “*Numerical Methods for Engineers*” , McGraw Hill Publication, 6th edition.
2	Hines and Montrogmery , “*Probability and Statistics in Engineering and Management Studies*” , John Willey Publication.
3	Santosh Gupta, “*Numerical Methods for Engineers*”, New age international publishers, 3rd edition.
References	
1	C. Godsil and G. Royle, “*Algebraic Graph Theory*”, Springer, New York, 2001
2	R. B. Bapat , “*Graphs and Matrices*” , TRIM Series, Hindustan Book Agency, 2nd edition,2011
Useful Links	
1	https://nptel.ac.in/courses/103/106/103106074/

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1				3		
CO2				3		
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
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	10	10	30	**50**
Apply	10	10	30	**50**
Analyze				
Evaluate				
Create				
Total	**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M.Tech., Sem II
Course Code	5CS525
Course Name	Professional Elective 4: Neural Network and Fuzzy Control
Desired Requisites:	Engineering Mathematics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

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,

CO1	**Explain** Neural Networks and Fuzzy Control.	Understanding
CO2	**Apply** genetic algorithms and optimization in NN, fuzzy applications development.	Applying
CO3	**Analyze** Neural Networks and Fuzzy Controller algorithms.	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.	5

III	**Unsupervised Learning Networks** Associative learning- simple associative learning, Unsupervised Hebb, Modifications in Hebb, Instar and out star rule, Application to control.	5
IV	**Fuzzy Logic** Fuzzy mathematics, Fuzzy mapping, Fuzzy relations, Implication rules, Mamdani & Sugeno models, Fuzzy rule Base structure, FKBS systems, FKBC PID.	5
V	**Fuzzy Controller Design** Mamdani techniques, Takagi Sugeno Model, PDC techniques, Stability Analysis using matrix inequality, Application and implementation.	4
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.	4

Text Books	
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			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.

Assessment
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	10	5	20	**35**
Apply	10	5	20	**35**
Analyze		10	20	**30**
Evaluate				
Create				
Total	**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS526
Course Name	Professional Elective 4: Modern Signal Processing
Desired Requisites:	Digital Signal Processing

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

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,

CO1	**Apply** the least square algorithms to adaptive signal processing	Applying
CO2	**Use** of Embedded processors for DSP applications	Applying
CO3	**Analyze** adaptive and kalman filter.	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.	4
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.	4

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.	5
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	5
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	4
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.	4

Text Books	
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 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	20	10	40	**70**
Analyze		10	20	**30**
Evaluate				
Create				
Total	**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS575
Course Name	Activity Based Elective Lab for Neural Network and Fuzzy Control
Desired Requisites:	Engineering Mathematics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**Lab ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/Week				
Interaction	-	**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,

CO1	**Demonstrate** the Neural Networks and Fuzzy Control techniques.	Applying
CO2	**Analyze** different Neural Networks and Fuzzy Control	Analyzing
CO3	**Evaluate** different Neural Networks and Fuzzy Control	Evaluating

List of Experiments / 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.

Text Books

1	M.T.Hagan, H.B.Demuth, M.H.Beale, "*Neural Network Design*", PWS Publications, 1996
	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. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	10	10	20	**40**
Evaluate	10	10	10	**30**
Create				
Total Marks	**30**	**30**	**40**	**100**

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Course Information

Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5CS576
Course Name	Activity Based Elective Lab for Modern Signal Processing
Desired Requisites:	Digital Signal Processing

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**Lab ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/Week				
Interaction	-	**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,

CO1	**Demonstrate** the least square algorithms to adaptive signal processing.	Applying
CO2	**Analyze** adaptive and kalman filter.	Analyzing
CO3	**Experiment** with Embedded processors for DSP applications.	Analyzing

List of Experiments / 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.

Text Books

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. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities, attendance	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	Lab activities, attendance	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

Assessment Plan based on Bloom's Taxonomy Level (Marks) (For lab Courses)				
Bloom's Taxonomy Level	**LA1**	**LA2**	**Lab ESE**	**Total**
Remember				
Understand				
Apply	20	20	20	**60**
Analyze	10	10	20	**40**
Evaluate				
Create				
Total Marks	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5OE107
Course Name	Open Elective I: Control Techniques for Electrical Drives
Desired Requisites:	

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

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,		
CO1	**Explain** various concept used in AC and DC drives.	Understand
CO2	**Apply** control techniques to AC and DC drives.	Apply
CO3	**Analyze** control techniques for AC and DC drives.	Analyze
CO4	**Evaluate** various control schemes of AC and DC drives.	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.	4
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	5

	operation, chopper control of DC shunt motor drives, four quadrant operation of chopper fed DC shunt motor drive.	
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.	5
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.	5
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.	5
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.	4

Text Books	
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)						
	1	2	3	4	5	6
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 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	10		10	20
Apply	10	10	20	40
Analyze		10	20	30
Evaluate			10	10
Create				
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Control System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	5IC502
Course Name	Value Education
Desired Requisites:	

Teaching Scheme	**Examination Scheme (Marks)**				
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 0**			

Course Objectives	
1	To impart knowledge on value of education and self- development.
2	To imbibe good values in students.
3	To highlight importance of character.

Course Outcomes (CO) with Bloom's Taxonomy Level		
At the end of the course, students will be able to,		
CO1	**Explain** value of education and self- development.	Understand
CO2	**Summarize** importance of good character, and Behaviour development.	Evaluate

Module	**Module Contents**	**Hours**
I	Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism, Moral and non- moral valuation. Standards and principles, Value judgments.	6
II	Importance of cultivation of values, Sense of duty. Devotion, Self-reliance, confidence, Concentration. Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National Unity, Patriotism, Love for nature, Discipline.	6
III	Personality and Behaviour Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour universal brotherhood and religious tolerance, True	7

	friendship, Happiness vs. suffering, love for truth, Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature	
IV	Character and Competence –Holy books vs. Blind faith, Self-management and Good health, science of reincarnation, Equality, Nonviolence, Humility, Role of Women, All religions and same message, Mind your Mind, Self-control. Honesty, Studying effectively	7
Text Books		
1	Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi	
References		
1	-	
Useful Links		
1	https://nimsuniversity.org/wp-content/uploads/2018/02/Value-Education-Human-Rights-and-Legislative-Procedures.pdf	
2	http://cbseacademic.nic.in/web_material/ValueEdu/Value%20Education%20Kits.pdf	
3	https://www.verywellmind.com/personality-development-2795425	
4	https://trudreadz.com/2019/09/10/blind-faith-in-religion-destroys-our-ability-to-critically-think-for-ourselves/	

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1	2				1	2
CO2	1		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 (for Theory Course)
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level (Marks) For Theory Course					
Bloom's Taxonomy Level		**T1**	**T2**	**ESE**	**Total**
1	Remember				
2	Understand	10	10	30	**50**
3	Apply				
4	Analyze				
5	Evaluate	10	10	30	**50**
6	Create				
Total		**20**	**20**	**60**	**100**