

**B. Tech. Year II: Semester – 4**

**Subject Name: Control Theory**

**Subject Code: BTIC13404**

**Type of course: PCC**

**Prerequisite (if any):** Basic knowledge of Mathematics, physics, electricity, especially integration, differentiation and complex numbers, Laplace Transformation, matrices, determinants and solutions of differential equations.

**List of Courses where this course will be prerequisite:** control system design

**Rationale:** This course will provide the students (i) the overview of the basics of control systems(ii) carry out analysis of simple and complex systems (iii) applications of the theory to real world systems (iv) the methods to derive the mathematical model of real systems.

**Teaching and Examination Scheme:**

TEACHING SCHEME				Theory Marks			Practical Marks		Total
L	T	P	C	TEE	CA1	CA2	TEP	CA3	
3	0	2	4	60	25	15	30	20	150

**CA1: Continuous Assessment (assignments/projects/open book tests/closed book tests CA2: Sincerity in attending classes/class tests/ timely submissions of assignments/self-learning attitude/solving advanced problems TEE: Term End Examination TEP: Term End Practical Exam (Performance and viva on practical skills learned in course) CA3: Regular submission of Lab work/Quality of work submitted/Active participation in lab sessions/viva on practical skills learned in course**



**Content:**

Sr. No.	Content/Topics	Total Hrs	Module weightage%
1	<p>Introduction and mathematical modeling of continuous LTI systems</p> <p>Importance of control theory, real examples of control systems, brief overview of Laplace Transformation, types of systems like Linear Time Variant(LTV), Linear Time Invariant(LTI), nonlinear(brief introduction), distributed and lumped parameter systems(brief introduction), very brief overview of Laplace Transformation, introduction to system gain and transfer functions, feedback control, importance of feedback control systems, block diagrams representation and analysis, signal flow graphs, mason's gain formula, derive the models for RLC circuits (e.g. find transfer function of series RLC circuit considering capacitor voltage as output and pure DC input voltage), modeling of mechanical systems like spring-mass-dashpot systems, modeling of liquid level tank systems, modeling of gear train systems.</p>	12	26
2	<p>Concepts of stability and the root locus technique</p> <p>Type and order of the systems, poles and zeros of the system, first and second order systems, damping ratio, settling time, rise time, peak overshoot and stability criteria, Routh Hurwitz criteria, why poles must lie on the left half of the s-plane for stability, critical gain, conditions for sustained oscillations, error/steady state error. Standard test inputs like step, ramp and sine wave. Concepts of root locus, method to obtain root locus plot. Relative stability concepts, robustness, parameter insensitivity, effects of adding poles (can be shown with simulation) or zeros on root locus and stability of LTI systems. Brief introduction to PID modes of action in feedback control systems.</p>	12	26
3	<p>Frequency domain analysis</p> <p>Importance of frequency domain analysis, Bode plot and Nyquist plots. Gain</p>	12	26



	and Phase margin, relative stability analysis with Bode plots and Nyquist plots, Nyquist stability criteria. Relation between time and frequency domain parameters, effects of adding poles or zeros on Bode plot. Bode plots and Nyquist plots for time delay systems.		
<b>4</b>	Importance of state space modeling and analysis, introduction to state space modeling of simple LTI systems, obtain state space models of systems from transfer function (e.g. RLC circuit). Eigen values and poles of the systems, stability in state space.	<b>9</b>	<b>22</b>

**Suggested Specification table with Marks (Theory): (For B. Tech. only)**

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
<b>10</b>	<b>30</b>	<b>10</b>	<b>30</b>	<b>10</b>	<b>10</b>

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom’s Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

**Reference Books:**

Sr no	Title of book /article	Author(s)	Publisher and details like ISBN	Year of publication	Publication Edition
1	Modern Control Engineering	K. Ogata	PHI, ISBN-13. 978-0136156734	1997	3rd
2	Automatic Control	B. Kuo	PHI, ISBN-10 :	1995	7 <sup>th</sup>

**BSC: basic science course /ESC: Engineering Science Course /HSM: Humanities and management /PCC: Professional Core course /PEC: professional Elective course /OEC: Open Elective course/ MD: mandatory noncredit course**



**SARVAJANIK UNIVERSITY**  
**Sarvajani College of Engineering and**  
**Technology**  
**Bachelor of Technology**



	Systems		978812655233 7		
3	Control System Engineering	Norman Nise	Wiley, ISBN-13-978-1118170519	2018	--

**Course Outcomes: After successfully completing this course, the student will be able to,**

Sr. No.	CO statement	Marks % weightage
CO-1	model and analyze the simple real world systems,	40%
CO-2	carry out analysis of complex systems for stability,	30%
CO-3	describe the LTI system behavior for the given inputs,	10%
CO-4	simulate linear systems with computer software,	10%
CO-5	derive state space model for simple LTI systems,	10%

Mapping CO-POs-PSO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	3	2									3		
CO2		2			1	2								3	
CO3						2	1	1	1					2	2
CO4										1	2	2		3	
CO5		2	3										2		

**List of Open learning website:**

1. <https://ocw.mit.edu/courses/mechanical-engineering/2-04a-systems-and-controls-spring-2013/syllabus/>
2. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-241j-dynamic-systems-and-control-spring-2011/syllabus/>

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### **NPTEL lectures on signals and systems**

Control engineering

By Prof. RamkrishnaPasumarthy | IIT Madras

[https://onlinecourses.nptel.ac.in/noc22\\_ee31/preview](https://onlinecourses.nptel.ac.in/noc22_ee31/preview)

### **List of Open Source Software:**

**Scilab/xcos/scicos simulation software**

### **FOR LAB SESSIONS:**

#### **List of Experiments:**

1. Obtain block diagram for a given system and test it.
2. Sketch root locus and comment on the stability of the given system (prefer 3<sup>rd</sup> or 4<sup>th</sup> order system). Also explore the effects of varying poles and zeros and gain on system stability.
3. Obtain the response of the second order system. Vary the gain and pole/s and zeros of the system and find their effects on system behavior.
4. Obtain the First Order plus Time Delay (FOPTD) model for a given system IO responses.
5. Find the critical gain of the system from the root locus.
6. Implement in hardware RLC circuit. Obtain its response for step input. Also, verify it in simulation.
7. Implement the model of simple second order system and obtain its bode plot. Find gain and phase margins. Also, comment on stability. Also, try to obtain the bode plot for the systems with time delay.
8. Implement the model of simple second order system and obtain its Nyquist plot. Comment on its stability by observing the Nyquist plot.
9. Implement simple state space model for RLC circuit and simulate it for step input.
10. To study any closed loop system.
11. To study the effect of proportional control action for second order plant.

**Major Equipment Needed:** MATLAB/Scilab/Proteus/Multisim software/breadboard RLC circuits, Breadboard, power supply, DSO, CRO and other hardware practical kits/set ups for circuit analysis.

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