SARVAJANIK UNIVERSITY
Sarvajanik College of Engineering and Technology
Bachelor of Technology

B. Tech. III: Semester – VI

Subject Name: Control System Design **Subject Code: BTIC13603**

Type of course: PCC

Prerequisite (if any): Basic knowledge of Mathematics, especially integration, differentiation and complex numbers, control theory.

List of Courses where this course will be prerequisite: Optimal & Robust Control(Honors-2)

This course will provide the students (i) abstraction of control systems, from the point of view of analysis and design for robustness (ii) to analyze and design control systems for Linear Time Invariant (LTI) systems in time and frequency domains, state space and (iii) to design control systems for reference tracking and regulation of LTI 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:

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

Sr. No.	Content	Total Hrs	%weightage
1	**Overview to control theory** Introduction and classical control theory, root locus and bode plots techniques, transfer function and state space representation of the systems, relative stability, Gain and Phase Margin and its significance.	03	6%
2	**Design of Control Systems in Time Domain** Control system design with root locus technique, design specifications in terms of peak overshoot and settling time, cascade Phase lead and Phase lag compensators design, practice examples and computation techniques. Compensator design with analog circuits.	08	18%
3	**Design of Control Systems in Frequency Domain** Design of the control systems with Bode Plot Technique, specifications in terms of Gain Margin and Phase Margin, design of cascade phase lead and phase lag compensators. Practice examples and compensation techniques.	08	18%
4	**State Space Analysis** Transfer function vs state space representation. State space representation of the systems, controllable canonical form, observable canonical form, diagonal canonical form representation, transfer function to state space and state space to transfer function conversion, stability, solution of the state space equation and state transition matrix, controllability and observability of the LTI systems.	08	18%
5	**State Space Design** State feedback , Ackerman's formula, direct pole placement state observer design, regulation and reference tracking in state space, multivariable state feedback, design as per given specifications i.e. in terms of peak overshoot , settling time etc., demonstration/simulation of inverted pendulum system with state feedback, Lyapunav stability criteria, positive definite and positive semidefinite functions, cost function, optimal control theory, and Riccatti equation, Linear Quadratic Regulator (LQR) design	10	22%
6	**Introduction nonlinear systems and analysis** Nonlinear systems, Multiple Equilibria, Qualitative Behavior Near Equilibrium Points, some common nonlinear elements, stability analysis, describing functions, limit cycles, phase plane analysis, Numerical Construction of Phase	08	18%

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	Portraits, existence of periodic orbits, bifurcation, perturbed systems.		

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20%	**20%**	**20%**	**20%**	**10%**	**10%**

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	Pearson Education India; 5th edition (1 January 2015) • ISBN-10 : 9789332550162 • ISBN-13 : 978-9332550162	2015	5th
2	Control Systems Principles and Design	M.Gopal	McGraw Hill Education • ISBN-10 : 9780071333269 • ISBN-13 : 978-0071333269	2012	4th

3	Modern Control Systems, Global Edition	Richard Dorf, Robert Bishop	Pearson, • ISBN-10 : 1292152974 • ISBN-13 : 978-1292152974	2017	Global Edition
4	Nonlinear Systems	Hasan Khalil	Pearson Education India • ISBN-10 : 9332542031	2014	3rd

Course Outcomes: after successful completion of this course the students will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	apply the fundamentals of control theory to control design	20%
CO-2	use the graphical methods for compensator design	20%
CO-3	evaluate the performance of closed loop system and system behavior	20%
CO-4	analyze nonlinear systems	10%

	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2										1		
CO2			2	3	2	2	2							1	1
CO3					2	2	2	1	1	1				2	2
CO4										2	1	1	1	1	1

List of learning website:

NPTEL, SWAYAM, EDX, Coursera websites

NPTEL lectures control systems design
List of Open Source Software: Scilab simulation software

FOR LAB SESSIONS:

List of Experiments:

1. Design and simulate phase lead compensator for given LTI system with root locus technique.
2. Design and simulate phase lag compensator for given LTI system with root locus technique.
3. Design and simulate phase lead compensator for given LTI system with Bode Plot technique.
4. Design and simulate phase lag compensator for given LTI system with Bode Plot technique.
5. Implementation of compensator for a given LTI system with software/hardware tools.
6. Design state feedback controller for a given LTI system.
7. Design state observer for a given LTI system.
8. Design reference tracking controller for a system given in state space.
9. Design state feedback controller for MIMO system.
10. Design two degree of freedom control action for disturbance rejection.
11. Microcontroller implementation of PI controller.

Major Equipment Needed: Computer Lab **,** MATLAB/Scilab software

Op-Amps./microcontroller/other hardware setup if available.