SARVAJANIK UNIVERSITY
Sarvajanik College of Engineering and Technology
Bachelor of Technology

B. Tech. Semester IV ELECTRICAL ENGINEERING

Subject Name: Control System Engineering **Subject Code: BTEL13405**

Type of course: **Engineering Science**

Prerequisite: Basic knowledge of Laplace and inverse Laplace Transform and Differential Calculus. Basic knowledge of Mechanics and Electrical Systems

Rationale: An automatic control system saves manpower, reduces cost of production, increases the accuracy of the finished product and helps in mass production. This subject helps To develop a comprehensive knowledge and understanding of classical and modern control theory, industrial automation, and systems analysis. Control engineering is a diverse and rapidly expanding discipline which has become increasingly important in a wide range of industries.

Teaching and Examination Scheme:

TEACHING SCHEME				Theory Marks			Practical Marks		Total
L	T	P	C	TEE	CA1	CA2	TEP	CA3	150
3	0	2	5	60	25	15	30	20	

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.	Topics	Teaching Hrs.	Module % Weightage
1.	**Basic concepts of control system:** Terminology - plant, process, system, disturbances, controlled variable, manipulated variable etc., Block diagram of basic control system, application areas with examples. Advantages of closed loop system. Classifications of control systems, Concept of superposition for linear systems with examples.	4	10%

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2.	**Mathematical modelling of systems:** Introduction to Translational and rotational mechanical, electrical, thermal, hydraulic and pneumatic systems, Force voltage and force current analogy, Position servo mechanism. Block diagram and signal flow graph representation of physical systems , comparison and limitation, Mason's gain formula	**9**	**20%**
3.	**Time response analysis:** Standard test signals along with examples of their usage, steady state errors for step, ramp and parabolic inputs, analysis of first and second order systems, Transient response specifications with numerical examples, Basic control actions and two position, proportional, PI, PID and rate feedback controllers, Limitations of time domain analysis.	**8**	**20%**
4.	**Frequency response analysis:** Need of frequency response analysis, Sinusoidal response of linear system, performance specification in frequency domain-Frequency response of standard second order system- Bode Plot — Polar Plot-Nyquist plots	**9**	**20%**
5.	**Stability:** Concept of stability, types of stability, Routh's stability criterion, special cases with numerical examples, stability of closed loop system, concept of root locus, open loop and closed loop transfer poles, step by step procedure for root loci	**7**	**15%**
6.	**State space analysis:** Concepts of state, State variables and state models, State space equations, Transfer function, Transfer model, State space representation of dynamic systems, State transition matrix, Decomposition of transfer function, Controllability and observability.	**8**	**15%**

Suggested Specification table with Marks (Theory/Practical):

% Distribution of Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	10	25	20	20	10

Legends: R: Remembrance, **U:** Understanding; **A:** Application, **N:** Analyze, **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.

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Reference Text Books:

Sr. No.	Title of book /article	Author(s)	Publisher and details like ISBN	Year of publication	Publication Edition
1	Control System Engineering	J. Nagrath and M.Gopal	New Age International Publishers	2007	Fifth Edition
2	Modern control theory	Katsuhiko Ogata	Pearson Education International,		Fifth Edition.
3	Automatic control systems,	Farid Golnaraghi, Benjamin C Kuo	John Wiley & Sons, Inc		Nineth Edition.
4	Modern Control Systems	Richard C. Dorf, Robert H Bishop	Pearson Education International		Twelfth Edition.
5	Control Systems	Ashok Kumar	McGraw Hill Education India	2005	First Edition.

Course Outcome:

Sr. No.	CO Statement After learning this subject, students will be able to	Marks % weightage
CO-1	Analyze the process of modeling linear time-invariant (LTI) dynamical systems in dual domains: in the time domain using ordinary differential equations and in the Laplace domain (s-domain).	**15%**
CO-2	Explain and analyze the behavior of LTI systems qualitatively and quantitatively, both in the transient and steady-state regimes, and appreciate how it impacts the performance of electro-mechanical systems.	**25%**
CO-3	Apply the concepts of feedback control using the s-domain primarily, and analyze how feedback impacts transient and steady-state performance	**10%**
CO-4	Design and implement proportional, proportional-integral, proportional-derivative, and proportional-integral-derivative feedback control systems meeting specific system performance requirements.	**15%**
CO-5	Evaluate the qualitative frequency response of LTI systems and its relation to the transient and steady-state system performance	**20%**

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CO-6	Understand and apply the concept of state-space models and their relation to frequency domain models. Create, design and evaluate the State space response for LTI systems. Cayley Hamilton Theorem, observabilty, controllability and draw the duality between them.	15%

Mapping with POs:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO3**
CO-1	3	3	1	2	3				2	2	2	2	3	2	
CO-2	3	3	2	2	3				2	2	2	2	3	2	
CO-3	3	3	2	2	3				2	2	2	2	3	2	
CO-4	3	3	2	2	3				2	2	2	2	3	2	
CO-5	3	3	2	2	3				2	2	2	2	3	2	
Rationale *															

Rationale*: Explaining why it is matching this particular program outcome

LIST OF PRACTICALS: (Minimum ------ performed.)

1. Introduction to simulation software like MATLAB/LABVIEW
2. To study performance characteristic of D.C. motor speed control system
3. Study of small A.C. servo motor and to obtain its transfer function
4. Modelling of physical system using simulation software
5. Simulation of linear 1st and 2nd order system to different inputs.
6. Evaluation of Time domain performance specifications of 1st and 2nd order system using simulation software
7. Simulation of root locus plot using simulation software
8. Frequency domain analysis of various transfer functions using simulation software
9. State Space representation and performance Analysis of second and third order systems.
10. Design of PID controller for 1st and 2nd order system (or speed control of D.C. motor system)

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List of Open Source/learning website:

- https://en.wikipedia.org/wiki/Control_engineering
- https://ledin.com/control-systems-basics/
- https://ocw.mit.edu/courses/mechanical-engineering/2-04a-systems-and-controls-spring-2013/
- https://umdearborn.edu/cecs/graduate-programs/certificates/control-systems
- https://nptel.ac.in/courses/108/106/108106098/ (video course)
- https://nptel.ac.in/courses/112/104/112104158/
- https://ctms.engin.umich.edu/CTMS/index.php?example=Introduction&section=SystemModeling
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For Lab

- https://in.mathworks.com/videos/series/control-systems-in-practice.html
- http://homepages.ed.ac.uk/jwp/control06/controlcourse/course/map/index.html
- https://www.iitg.ac.in/cseweb/vlab/Signal-System-Lab/signalsystem/Signals%20and%20their%20properties(objectives).html

List of Open Source Software:

- https://www.scilab.org
- www.simscale.com