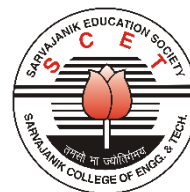




**SARVAJANIK UNIVERSITY**  
**Sarvajani College of Engineering and Technology**  
**Bachelor of Technology**



**B. Tech. Semester III**

**Subject Name:** Control Systems

**Subject Code:** BTEL13305

**Type of Course:** ESC

**Prerequisite:** Basic knowledge of Laplace and inverse Laplace Transform and Differential Calculus

**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	4	60	25	15	30	20	

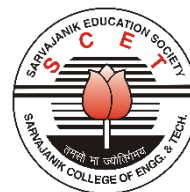
**CA1:** Continuous Assessment (assignments/projects/open book tests/closed book tests **CA2:** Sincerity in attending classes/class tests/ timely submissions of assignments/self-learning attitude/solving advanced problems **TEE:** Term End Examination **TEP:** Term End Practical Exam (Performance and 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.	<b>Basic concepts of control system:</b> 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.	5	15
2.	<b>Mathematical modelling of systems:</b> 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	8	20



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<b>3.</b>	<b>Time response analysis:</b> 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
<b>4.</b>	<b>Frequency response analysis:</b> 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
<b>5.</b>	<b>Stability:</b> 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	5	10
<b>6.</b>	<b>State space analysis:</b> 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.	7	15

**Suggested Specification table with Marks (Theory/Practical):**

<b>% Distribution of Marks</b>					
<b>R Level</b>	<b>U Level</b>	<b>A Level</b>	<b>N Level</b>	<b>E Level</b>	<b>C Level</b>
20	25	25	10	10	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.

**Reference Text Books:**

<b>Sr. No.</b>	<b>Title of book /article</b>	<b>Author(s)</b>	<b>Publisher and details like ISBN</b>	<b>Year of publication</b>	<b>Publication Edition</b>
<b>1.</b>	Modern control theory	Katsuhiko Ogata	Pearson Education International,		5 <sup>th</sup>



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2.	Control system engineering	Norman S Nise	John Wiley & Sons, Inc		6 <sup>th</sup>
3.	Modern Control Systems	Richard C. Dorf, Robert H Bishop	Pearson Education International		12 <sup>th</sup>
4.	Automatic control systems,	Farid Golnaraghi, Benjamin C Kuo	John Wiley & Sons, Inc		9 <sup>th</sup>
5.	Control System Engineering	J.Nagrath and M.Gopal	New Age International Publishers	2007	5 <sup>th</sup>

**Course Outcome:**

Sr. No.	CO Statement After learning this subject students will be able to	Marks % weightage
CO-1	Describe 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	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	Introduce feedback control and understand, using the s-domain primarily, how feedback impacts transient and steady-state performance	10
CO-4	Explain how to design proportional, proportional-integral, proportional-derivative, and proportional-integral-derivative feedback control systems meeting specific system performance requirements.	15
CO-5	Introduce qualitatively the frequency response of LTI systems and how it relates to the transient and steady-state system performance	20
CO-6	Analyze concept of state-space models and their relation to frequency domain models. Obtain the State space response for LTI systems. Cayley Hamilton Theorem, observability, controllability and duality between them.	15

**Mapping with POs:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	1	3					2		2	2
CO-2	3	3	2	3					2		2	2
CO-3	3	3	2	3					2		2	2
CO-4	3	3	2	3					2		2	2
CO-5	3	3	2	3					2		2	2

**List of Practical:**

1. Development of block diagram of various physical systems given by instructor ex. Toster system, watt governor etc.
2. Introduction to simulation software like MATLAB/LABVIEW



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3. Modeling of physical system using simulation software
4. Simulation of linear system to different inputs
5. Given a system transfer function, plot the location of the system zeros and poles using simulation software
6. Simulation of root locus plot using simulation software
7. Performance measurement of first and second order system using simulation system as given by instructor

**Design based problems (DP)/open ended problem:**

- Give a task to develop an open loop or closed loop control of physical system (Inverted Pendulum)
- Design P, PI and PID controller for speed control DC servo motor.

**ACTIVE LEARNING ASSIGNMENTS:** Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide.

**Major Equipment:**

1. Ac Servomotor (open loop and closed loop )
2. Dc Servomotor (open loop and closed loop )
3. Open loop/ Closed loop system simulator
4. Potentiometer
5. Magnetic Amplifier
6. MATLAB based practicals

**List of Open Source/learning website:**

- [https://en.wikipedia.org/wiki/Control\\_engineering](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>
- <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](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](http://www.simscale.com)