SARVAJANIK UNIVERSITY
Sarvajanik College of Engineering and Technology
Bachelor of Technology (Working Professional)

B. Tech. II Semester IV ELECTRICAL ENGINEERING

Subject Name: Control System Engineering **Subject Code: BTEL13381**

Type of course: **Engineering Science**

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	CAP	150
3	1	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:** Concept of control systems, classification of control system, Concepts of feedback, its effect on system performance indices like gain, sensitivity noise cancellation, and stabilty., Servomechanisms and regulators, examples of feedback control systems. Concept of transfer function, different represenations, Pole and Zeroes of a transfer function. Properties of Transfer function.	4	9%

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2.	**Mathematical modelling of systems:** Translational and rotational mechanical, electrical, thermal, hydraulic and pneumatic systems, Force voltage and force current analogy. Block diagram and signal flow graph representation of physical systems , comparison and limitation, Mason's gain formula	**7**	**15%**
3.	**Time response analysis:** Standard test signals, steady state errors for step, ramp and parabolic inputs, time domain analysis of first and second order systems, Transient and steady state performance indices, Basic control actions and two position, proportional, PI, PID and rate feedback controllers, Limitations of time domain analysis.	**10**	**22%**
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- Stability margins(performance indices)	**10**	**22%**
5.	**Stability:** Concept of BIBO stability for LTI systems, types of stability, Routh's and Routh-Hurwitz stability criterion, special cases, stability of closed loop system, Root Locus Technique, step by step procedure for root loci	**8**	**18%**
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.	**6**	**13%**

Suggested Specification table with Marks (Theory/Practical):

% Distribution of Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
15	**20**	**20**	**15**	**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.

ESC: Engineering Science Course

Reference Text Books:

Sr. No.	Title of book /article	Author(s)	Publisher and details like ISBN	Year of publication	Publication Edition
1	Modern control theory	Katsuhiko Ogata	Pearson Education International,		Fifth edition
2	Control system engineering	Norman S Nise	John Wiley & Sons, Inc		Sixth edition
	Modern Control Systems	Richard C. Dorf, Robert H Bishop	Pearson Education International		Twelfth Edition.
	Automatic control systems,	Farid Golnaraghi, Benjamin C Kuo	John Wiley & Sons, Inc		Ninth edition
	Control System Engineering	J.Nagrath and M.Gopal	New Age International Publishers	2007	Fifth Edition

Course Outcome:

Sr. No.	CO Statement After learning this subject, students will be able to	Marks % weightage
CO-1	Recognize control system and its types, and control actions.	10%
CO-2	Categorize different types of system and formulate their behaviour using a set of algebraic equations .and evaluate their transfer function of using block diagram and /or signal-flow graph techniques.	15%
CO-3	Employ time domain analysis to predict and diagnose transient performance par ameters of the system for standard input functions. time-domain techniques like Routh Hurwitz criteria and Root locus technique.	30%
CO-4	Inspect the relationship between time-domain and frequency domain response of second order system and analyze the systems performance using various frequency-domain techniques.	25%
CO-5	Acquire knowledge of basic concepts of state space modelling, representation, formulation and solution of state space of various types continuous LTI systems.	20%

Mapping with POs:

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Program Educational Objectives (PEOs)

PEO1: To demonstrate broad knowledge of electrical engineering technology to support design, application, installation, manufacturing, operation, and maintenance of not only electrical but also other diversified areas like electronic, computer and instrumentation system.

PEO2: To display the creative and critical reasoning skills to solve technical problems, ethically and responsibly, in benefit of society.

PEO3: To exhibit professional attitude, effective communication skills, team work skill and an ability to thrive in multi-disciplinary and diverse fields.

PEO4: To pursue professional development, including continuing or advanced education relevant to his/her career path and to motivate for life-long learning.

Program Specific Outcome (PSOs)

PSO1: Analyze, design and implement ideas and skills of electrical engineering independently and in groups to meet industrial and societal needs.

PSO2: Use recent simulation and programming tools for analysis of electrical circuits and systems.

PSO3: Evaluate clean energy options, energy efficient solutions and other alternatives for sustainable development.

Program Objective (PO)

Upon successful completion of the program, electrical engineering graduates are expected to

1. Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. Identify, formulate, and analyze complex engineering problems based on fundamentals and principles of engineering to suggest practical solutions.
3. Design and conduct experiments, as well as to analyze and interpret data.
4. Apply critical thinking in designing and validating components, processes and systems especially related to Electrical Engineering.
5. Design and analyze Electrical and/or Electronic systems with an aid of suitable modern application tools/packages.
6. Value professional, ethical and social responsibilities and an impact of engineering on society.
7. Evaluate the consequences of engineering and technological advancement on environment and need for sustainable development.
8. Communicate effectively.
9. Develop confidence for self education and life-long learning.
10. Work effectively as an individual and in a team.
11. Use the techniques and skills to face and succeed in competitive examinations like GATE, GRE, TOFEL, etc.

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	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	PSO 3
CO-1	3	3	3	3	3	2	2	1	3	1	1	1	**3**	**3**	
CO-2	3	3	3	2	3	2	2	1	3	1	1	1	**3**	**3**	
CO-3	3	2	2	2	2	2	2	1	2	1	1	1	**3**	**3**	
CO-4	3	2	2	1	2	2	2	1	1	1	1	1	**3**	**3**	
CO-5	3	3	3	3	1	2	3	1	2	1	1	1	**3**	**3**	
Rationale*															

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

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

1. Development of block diagram of various physical systems given by instructor ex. Servo systems, Electrical transmission lines , inverted pendulum etc.
2. Introduction to simulation software like MATLAB/LABVIEW
3. Modelling 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. Performance measurement of first and second order system using simulation system as given by instructor
7. Simulation of root locus plot using simulation software
8. Simulation of Bode plot and its analysis using simulation software
9. Obtaining the state space formulaion of LTI system, controllability and observability

Design based problems (DP)/open ended problem:

1. Give a task to develop an open loop or closed loop control of physical system (Inverted Pendulum

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2. 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. MATLAB based practicals

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/

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