GANPAT UNIVERSITY									
FACULTY OF ENGINEERING & TECHNOLOGY									
Programme	Bachelor of Technology					Branch/Spec.	Biomedical Engineering		
Semester	IV					Version	2.0.0.1		
Effective from Academic Year			2023-2024			Effective for the batch Admitted in			July 2022
Subject code	2BM4102		Subject Name			Control System Engineering			
Teaching scheme						Examination scheme (Marks)			
(Per week)	Lecture(DT)		Practical(Lab.)		Total		CE	SEE	Total
	L	TU	P	TW					
Credit	4	-	1	-	5	Theory	40	60	100
Hours	4	-	2	-	6	Practical	30	20	50

Pre-requisites
Basic knowledge of electrical & Mechanical Components, Linear differential equations, Laplace and Inverse Laplace transform.

Course Outcomes	
On successful completion of the course, the students will be able to:	
CO1	**Identify** Control system with and without feedback and control system components.
CO2	**Analyze** characteristics of physical systems with Mathematical model.
CO3	**Evaluate** system performance parameters and **explain** the behavior of closed loop systems in time domain and frequency domain.
CO4	**Discuss** the system stability performance with Root Locus, Routh Hurwitz, Bode plot, Polar plot and Nyquist criteria.

Theory syllabus

Unit	Content	Hrs.
	Introduction to the overview and importance of the course**.**	
1	INTRODUCTION CONTROL SYSTEMS: History of automatic control, Types of control system: Manual and Automatic control system, Open loop and Close loop control systems, Linear and Nonlinear Control System, Time variant and Time invariant control system, Block diagram representation of control system, Examples of control systems.	4
2	MATHEMATICAL MODELING AND TRANSFER FUNCTION: Mathematical models of Mechanical and Electrical systems. Analogy system, Transfer functions of mechanical and Electrical systems. Block diagram of a closed loop systems, Block diagram reduction technique, Signal flow graphs technique: signal flow graph terms, properties, signal flow graph algebra, mason's gain formula. Examples to derive TF using various methods.	8
3	GENERAL FEEDBACK CHARACTERISTICS: Importance of feedback in control system, Reduction of parameter variation and sensitivity, Effect of feedback on band width, Effect of feedback on system dynamics, Effect of feedback in presence of disturbances, Regenerative feedback and its use in control system, Advantages and Disadvantages of feedback. Examples to calculate system sensitivity.	5
4	CONTROL SYSTEM COMPONENTS: Elements of a control system, **Error detectors:** Potentiometers, Synchro, Servo Amplifiers- Amplidyne, Magnetic Amplifier, Actuators- DC and AC servo motors, Stepper Motors, Feedback components- DC and AC Tachogenerators, Optical incremental and absolute encoders, Control system Models of position and speed controls, Instrument servomechanism.	5
5	TIME DOMAIN ANALYSIS: Transient Response, standard test signals, Time response of first and second order system, Time response specifications, Transient response specifications of second order systems, Steady state response, Evaluation of steady state error and Error constants, Steady state error of second order	9

	system, Effect of control actions on transient response, Effect of Integral control on transient response, Effect of Zero on transient response. Examples to calculated various system performance parameters.	
6	STABILITY ANALYSIS: Characteristic equations of closed loop control systems and stability concept, Locus of complex conjugate roots, Poles and Zeros of transfer function. Routh and Hurwitz stability criterion, Relative stability. Examples to calculate stability and relative stability using above methods.	6
7	ROOT LOCUS TECHNIQUES: Basis of root locus, construction rules for sketching root locus. Examples to calculate stability using RLT.	5
8	FREQUENCY DOMAIN ANALYSIS: Frequency response of a control system, Frequency response of second order system, Performance specifications in frequency domain, Correlation between time response and frequency response, Normalized bandwidth, Polar Plots, Bode diagrams- concept of logarithmic plots, bode plots of standard terms, stability from bode plot, gain and phase margins. Examples to calculate system stability using Bode plot and Polar plot.	9
9	NYQUIST STABILITY CRITERION: Principle of argument, Nyquist criterion, Nyquist contour modification for poles on jw axis, Relative stability from Nyquist criterion, Gain and Phase margins. Example of Nyquist Stability criteria.	5
10	STATE VARIABLE ANALYSIS AND DESIGN: Introduction, Concept of State, State Variables and State Model, State model of Linear Continuous-Time System, Diagonalization, Solution of state equations, Concept of Controllability and Observability. Examples.	4

Practical content**:**	
Term Work and Practical shall be based on the above syllabus.	
Text Books**:**	
1	Control Systems Engineering by I.J.Nagrath and M.Gopal
2	Modern Control Engineering by K.Ogata
Reference Books **:**	
1	Control System Engineering by Prof. H.T. Kashipara
2	Elements of Control Systems by Sudhir Gupta
3	Automatic Control Systems by Benjamin C. Kuo and FaridGolnaraghi
ICT References **:**	
1	https://nptel.ac.in/courses/108101037/1/2/3/4/5/6/.....
2	https://nptel.ac.in/courses/108102043/1/2/3/4/5/6.....

Mapping of CO with PO and PSO:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1
CO2	2	3	1	1	0	0	0	0	0	0	0	0	3	2	0
CO3	2	0	1	0	1	0	0	0	0	0	0	0	2	2	0
CO4	0	2	2	1	1	0	0	0	0	0	0	0	3	2	0