SEMESTER V

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MR3492	Embedded Systems and Programming	PCC	2	0	2	4	3
2.	RA3501	Robot Path Planning and Programming	PCC	3	0	0	3	3
3.		Professional Elective I	PEC	-	-	-	-	3
4.		Professional Elective II	PEC	-	-	-	-	3
5.		Professional Elective III	PEC	-	-	-	-	3
6.		Professional Elective IV	PEC	-	-	-	-	3
7.		Mandatory Course-I[&]	MC	3	0	0	3	0
PRACTICALS								
8.	MR3561	Industrial Automation Laboratory	PCC	0	0	4	2	2
			TOTAL	**8**	**0**	**6**	**12**	**20**

[&] Mandatory Course-I is a Non-credit Course (Student shall select one course from the list given under MC- I)

SEMESTER VI

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	RA3601	Robot Dynamics and Control	PCC	3	0	0	3	3
2.		Open Elective – I*	OEC	3	0	0	3	3
3.		Professional Elective V	PEC	-	-	-	-	3
4.		Professional Elective VI	PEC	-	-	-	-	3
5.		Professional Elective VII	PEC	-	-	-	-	3
6.		Professional Elective VIII	PEC	-	-	-	-	3
7.		Mandatory Course-II[&]	MC	3	0	0	3	0
8.		NCC Credit Course Level 3[#]		3	0	0	3	3[#]
PRACTICALS								
9.	RA3611	Robot Kinematics and Dynamics Laboratory	PCC	0	0	4	4	2
9.	RA3612	Mini Project	EEC	0	0	2	2	1
			TOTAL	**12**	**0**	**6**	**18**	**21**

***Open Elective – I shall be chosen from the emerging technologies.**

[&] Mandatory Course-II is a Non-credit Course (Student shall select one course from the list given under MC- II)

[#] NCC Credit Course level 3 is offered for NCC students only. The grades earned by the students will be recorded in the Mark Sheet, however the same shall not be considered for the computation of CGPA

VERTICAL 4: INTELLIGENCE SYSTEMS

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CRA340	Applied Signal Processing	PEC	3	0	0	3	3
2.	CRA341	Applied Image Processing	PEC	3	0	0	3	3
3.	CRA342	Machine Learning for Intelligent Systems	PEC	3	0	0	3	3
4.	CMR340	Condition Monitoring and Fault Diagnostics	PEC	3	0	0	3	3
5.	CMR341	Systems Modelling and Simulation Methods	PEC	3	0	0	3	3
6.	CMR342	Optimization Techniques	PEC	3	0	0	3	3
7.	CMR343	Immersive Technologies and Haptics	PEC	3	0	0	3	3
8.	CMR344	Computer Vision and Deep Learning	PEC	3	0	0	3	3

VERTICAL 5: AUTOMATION

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMR345	Object Oriented Programming in C++	PEC	3	0	0	3	3
2.	EE3591	Power Electronics	PEC	3	0	0	3	3
3.	CMR358	Computer Architecture and Organisation	PEC	3	0	0	3	3
4.	CMR359	Virtual Instrumentation	PEC	3	0	0	3	3
5.	CMR346	Industrial Network Protocols	PEC	3	0	0	3	3
6.	CMR347	Motion Control System	PEC	3	0	0	3	3
7.	CMR348	Total integrated Automation	PEC	3	0	0	3	3
8.	CMR349	Digital Twin and Industry 5.0	PEC	3	0	0	3	3

VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CAE347	Avionics	PEC	3	0	0	3	3
2.	CAE348	Control Engineering	PEC	3	0	0	3	3
3.	CAE349	Guidance and Control	PEC	3	0	0	3	3
4.	CAE350	Navigation and Communication System	PEC	3	0	0	3	3
5.	CAE351	Design of UAV systems	PEC	3	0	0	3	3
6.	CAE352	Aerodynamics of Drones	PEC	3	0	0	3	3

VERTICAL 7: DIVERSIFIED COURSES GROUP 1

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMR351	Linear Integrated Circuits	PEC	3	0	0	3	3
2.	CMR352	Single Board Computers	PEC	3	0	0	3	3
3.	CMR353	Reliability and Maintenance Engineering	PEC	3	0	0	3	3
4.	CMR354	Integrated Product Development	PEC	3	0	0	3	3
5.	CMR355	Medical Mechatronics	PEC	3	0	0	3	3
6.	CMR356	Micro Electro Mechanical Systems	PEC	3	0	0	3	3
7.	CME396	Process Planning and Cost Estimation	PEC	3	0	0	3	3
8.	CMR357	VLSI and FPGA	PEC	3	0	0	3	3

OPEN ELECTIVES

(Students shall choose the open elective courses, such that the course contents are not similar to any other course contents/title under other course categories).

OPEN ELECTIVE I AND II
(EMERGING TECHNOLOGIES)

To be offered other than Faculty of Information and Communication Engineering

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OCS351	Artificial Intelligence and Machine Learning Fundamentals	OEC	2	0	2	4	3
2.	OCS352	IoT Concepts and Applications	OEC	2	0	2	4	3
3.	OCS353	Data Science Fundamentals	OEC	2	0	2	4	3
4.	CCS333	Augmented Reality /Virtual Reality	OEC	2	0	2	4	3

RA3601 **ROBOT DYNAMICS AND CONTROL** **LT P C**
3 0 0 3

COURSE OBJECTIVES

1. To learn and understand generalized co-ordinates, Jacobian matrix Mass Distribution and other fundamental equations.
2. To understand Lagrangean and Hamiltonian mechanics
3. To understand nonlinearities in control system
4. To Understand various force control strategies
5. to understand various concepts in linearizing a no linear signal

UNIT - I ROBOT FORCE MODELS **9**

Generalized co-ordinates - Generalized Forces - Equation of Motions – Static Forces in Manipulators - Jacobian matrix - Jacobians in The Force Domain - Cartesian Transformation of Velocities and Static Forces - Acceleration of A Rigid Body - Mass Distribution – Nonrigid Body Effects - Newton's Equation - Euler's Equation – Langrage Equation

UNIT - II ROBOT DYNAMICS **9**

General Expressions for Kinetic and Potential Energy - Kinetic Energy for an n-Link Robot - Potential Energy for an n-Link Robot - Equations of Motion -Lagrangian Multiplier - Langrage's Equation - Hamilton Equation - Hamilton vector Field- Euler - Langrage Equation – State Vector and Equation Formulation

UNIT - III ROBOT CONTROL SYSTEM **9**

The manipulator control problem, Linear second-order model of manipulator. Functions of controller and power amplifier. Joint actuators- stepper motor, servo motor. Control Schemes: PID control scheme – Position and force control schemes. Robotic sensors and its classification, Internal sensors – Position, velocity, acceleration and force information, External Sensors – Contact sensors-Limit switches, piezoelectric, pressure pads, Non-contact sensors – Range sensors, Vision sensor- robotic vision system, Description of components of vision system.

UNIT - IV CONTROL OF MANIPULATORS **9**

Linear Time Varying and Linearization – Input and Output Stability - Background: The Frobenius Theorem - Single-Input Systems. Introduction to nonlinear system – time varying systems - multi-input, multi-output control systems - the control problem for manipulators - practical considerations - current industrial-robot control systems - Lyapunov stability analysis – Cartesian - based control systems - adaptive control - Limit Cycle - Describing Function

UNIT - V FORCE CONTROL **9**

Constrained Dynamics - Static Force/Torque Relationships - Constraint Surfaces - Natural and Artificial Constraints - Network Models and Impedance - Impedance Operators - Classification of Impedance Operators - Force Control Strategies - Impedance Control - Hybrid Impedance Control.

TOTAL: 45 PERIODS

COURSE OUTCOME

CO1. Describe generalized co-ordinates, Jacobian matrix Mass Distribution and equation of motion.
CO2. Develop the static force model and inverse dynamic model of multi-degree of freedom (DOF) manipulator. Evaluate dynamics of robot using Lagrangian and Hamiltonian mechanics.
CO3. Describe the control architecture of robot manipulator.
CO4. Evaluate linear and nonlinearities in dynamics of robot.
CO5. Develop the control strategies for robot system

Mapping of COs with POs and PSOs

COs/POs &PSOs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	3		2						1	3	2	3
CO2	3	2	1	3		2						1	3	2	3
CO3	3	2	1	3		2						1	3	2	3
CO4	3	2	1	3		2						1	3	2	3
CO5	3	2	1	3		2						1	3	2	3
CO/PO & PSO Average	3	2	1	3		2						1	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

TEXT BOOKS:

1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar.
2. John J. Craig, "Introduction to Robotics – Mechanics and control", 3rd edition, Prentice hall, 2005.

REFERENCES:

1. Groover,M.P., Weis,M., Nagel,R.N. and Odrey,N.G., "Industrial Robotics Technology, Programming and Applications", McGraw-Hill, Int., 1986.
2. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill, 1987.
3. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd edition, John Wiley & sons, Inc., 2011
4. Klafter,R.D., Chmielewski, T.A. and Negin,M., "Robotics Engineering – An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 1984.

NCC Credit Course Level 3*

NX3651	(ARMY WING) NCC Credit Course - III	L T P C 3 0 0 3
PERSONALITY DEVELOPMENT		**9**
PD 3	Group Discussion: Team Work	2
PD 4	Career Counselling, SSB Procedure & Interview Skills	3
PD 5	Public Speaking	4
BORDER & COASTAL AREAS		**4**
BCA 2	Security Setup and Border/Coastal management in the area	2
BCA 3	Security Challenges & Role of cadets in Border management	2
ARMED FORCES		**3**
AF 2	Modes of Entry to Army, CAPF, Police	3
COMMUNICATION		**3**
C 1	Introduction to Communication & Latest Trends	3
INFANTRY		**3**
INF 1	Organisation of Infantry Battalion & its weapons	3
MILITARY HISTORY		**23**
MH 1	Biographies of Renowned Generals	4
MH 2	War Heroes - PVC Awardees	4
MH 3	Study of Battles - Indo Pak War 1965, 1971 & Kargil	9
MH 4	War Movies	6

TOTAL: 45 PERIODS

NCC Credit Course Level 3*

NX3652	(NAVAL WING) NCC Credit Course - III	L T P C 3 0 0 3
PERSONALITY DEVELOPMENT		**9**
PD 3	Group Discussion: Team Work	2
PD 4	Career Counselling, SSB Procedure & Interview Skills	3
PD 5	Public Speaking	4
BORDER & COASTAL AREAS		**4**
BCA 2	Security Setup and Border/Coastal management in the area	2
BCA 3	Security Challenges & Role of cadets in Border management	2
NAVAL ORIENTATION		**6**
NO 3	Modes of Entry - IN, ICG, Merchant Navy	3
AF 2	Naval Expeditions & Campaigns	3
NAVAL COMMUNICATION		**2**
NC 1	Introduction to Naval Communications	1
NC 2	Semaphore	1
NAVIGATION		**2**
N 1	Navigation of Ship - Basic Requirements	1
N 2	Chart Work	1
SEAMANSHIP		**15**
MH 1	Introduction to Anchor Work	2
MH 2	Rigging Capsule	6
MH 3	Boatwork - Parts of Boat	2
MH 4	Boat Pulling Instructions	2
MH 5	Whaler Sailing Instructions	3
FIRE FIGHTING FLOODING & DAMAGE CONTROL		**4**
FFDC 1	Fire Fighting	2
FFDC 2	Damage Control	2

SHIP MODELLING		**3**
SM	Ship Modelling Capsule	3

TOTAL : 45 PERIODS

NCC Credit Course Level 3*

		L T P C
NX3653	**(AIR FORCE WING) NCC Credit Course Level - III**	**3 0 0 3**

PERSONALITY DEVELOPMENT		**9**
PD 3	Group Discussion: Team Work	2
PD 4	Career Counselling, SSB Procedure & Interview Skills	3
PD 5	Public Speaking	4
BORDER & COASTAL AREAS		**4**
BCA 2	Security Setup and Border/Coastal management in the area	2
BCA 3	Security Challenges & Role of cadets in Border management	2
AIRMANSHIP		**1**
A 1	Airmanship	1
BASIC FLIGHT INSTRUMENTS		**3**
FI 1	Basic Flight Instruments	3
AERO MODELLING		**3**
AM 1	Aero Modelling Capsule	3
GENERAL SERVICE KNOWLEDGE		**2**
GSK 4	Latest Trends & Acquisitions	2
AIR CAMPAIGNS		**6**
AC 1	Air Campaigns	6
PRINCIPLES OF FLIGHT		**6**
PF 1	Principles of Flight	3
PF 2	Forces acting on Aircraft	3
NAVIGATION		**5**
NM 1	Navigation	2
NM 2	Introduction to Met and Atmosphere	3
AERO ENGINES		**6**
E 1	Introduction and types of Aero Engine	3
E 2	Aircraft Controls	3

TOTAL : 45 PERIODS

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

RA3611	ROBOT KINEMATICS AND DYNAMICS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

1. To model and simulate a robot and verify its kinematics
2. To model and simulate a robot and generate a trajectory plan.
3. To model and simulate a robot and verify its dynamics

LIST OF EXPERIMENTS

1. Verification of Forward Kinematics for 2R, 2P and RP Robot.
2. Verification of D-H transformation for 6DOF Serial manipulator
3. Verification of Inverse Kinematics for 2R, 2P and RP Robot.
4. Verification of Forward Kinematics for 3R spatial Robot.
5. Kinematic Analysis of 2R planar robot for varying trajectories using Robo analyzer
6. Workspace Analysis of 2R planar robot manipulator for a specified trajectory
7. Kinematic Analysis of 6 DOF robot for varying trajectories using Robo analyzer
8. Inverse Dynamic Analysis of 6 DOF robot robot for varying trajectories using Roboanalyzer
9. Forward and Inverse Dynamics of 2R planar robot using Roboanalyzer
10. Creation of Robot in ROS using Gazebo/V-REP
11. Motion Simulation of Robot in ROS using Gazebo/V-REP/Moveit/Industrial.
12. Simulation of Trajectory Analysis of 2R and 3R manipulators using MATLAB-SIMULINK

TOTAL: 30 PERIODS

COURSE OUTCOMES:

CO1: Analyze the kinematics and dynamics for various robots
CO2: Simulate and evaluate the kinematics and dynamics for various robots
CO3: Create a robot and program a trajectory plan for the robot.

Mapping of COs with POs and PSOs

COs/POs &PSOs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	1								1	2	2	3
CO2	3	2	1	1								1	2	2	3
CO3	3	2	1	1								1	2	2	3
CO/PO & PSO Average	3	2	1	1								1	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025