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RAMDEOBABA UNIVERSITY, NAGPUR

Formerly Shri Ramdeobaba College of Engineering & Management (RCOEM) Est. 1984

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RAMDEOBABA UNIVERSITY, NAGPUR–440013

(Formerly, Shri Ramdeobaba College of Engineering and Management, Nagpur 440013)

School of Engineering Sciences

Department of Mechanical Engineering

Teaching Evaluation Scheme and Syllabi

(As per National Education Policy-2020)

B. Tech. in Robotics and Artificial Intelligence

(With effect from Academic Year 2026-27)

Department of Mechanical Engineering

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Vision of the Department

Department of Mechanical Engineering aims to inculcate in students, a flair for excellence to become technological leader in industry and society.

Mission of the Department

1. To create the learning environment that stimulates students & faculty to enhance the knowledge in Mechanical Engineering.
2. To prepare the students to carry out research intended to cater the needs of the industry and society.
3. To march ahead with dedication, zeal and with a system responsive to the needs of all the stakeholders

Program Educational Objectives (PEOs)

PEO 1: Graduates will apply the principles of engineering fundamentals, robotics and artificial intelligence to identify, analyse, and develop innovative solutions for complex engineering problems in robotics and intelligent systems.

PEO 2: Graduates will excel in multidisciplinary professional environments by effectively collaborating with diverse teams and adapting to emerging technologies, industrial practices, and societal needs in automation, robotics, and artificial intelligence domains.

PEO 3: Graduates will demonstrate professional growth and leadership by communicating effectively, engaging in lifelong learning, and developing ethical, sustainable, and socially responsible robotic and AI-based solutions.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Program Outcomes (POs)

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyse and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

(WK*: The Knowledge and Attitude Profile)

Programme Specific Outcomes (PSOs)

PSO1: Apply principles of mechanical systems, electronics, control engineering, computer science, and artificial intelligence to analyze, model, and develop robotic systems for industrial and societal applications.

PSO2: Design, program, simulate, and integrate intelligent robotic systems using modern engineering tools, machine learning, computer vision, and robotic operating systems.

PSO3: Develop autonomous and intelligent solutions for real-world challenges through multidisciplinary approaches involving automation, data analytics, artificial intelligence, and human–robot interaction.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Guidelines for Accelerated Degree Program (ADP)

1. Outstanding/exceptional students (with a CGPA of 8.5 or above) may apply for the Accelerated Degree Program by applying along with a Statement of Purpose (SoP). Upon recommendation by the concerned department and approval from the competent authorities of RBU, such students may be permitted to complete an additional 30 credits by the end of the 6th semester.
2. The recommended NPTEL courses should preferably be aligned with the curriculum of the Program-Specific Electives and/or Program Core Courses offered in Semesters VII and VIII of the program.
3. NPTEL courses of 4-week and 8-week duration may be considered equivalent to 2 and 4 credits, respectively.
4. Projects undertaken during the 4^{th}, 5^{th}, and 6^{th} semesters shall be assigned additional weight age of 1, 2, and 3 credits, respectively.

Breakup of Semester wise Credits

Semester	Lecture	Practical	Self-learning	Credits	Continuous Evaluation	ESE Marks	Total Marks	No of Exams	Hours of ESE	Th Credits	Lab Credits
I	17	10	7	22	600	300	900	6	15	17	5
II	16	12	9	22	600	250	850	5	15	16	6
III	19	8	8	23	600	300	900	6	16	19	4
IV	15	12	7	21	550	250	800	6	14	15	6
V	17	12	8	23	650	300	950	6	16	17	6
VI	16	10	6	21	500	300	800	6	16	16	5
VII	10	14	36	18	450	200	650	4	10	10	7+1*=8
VIII	6	12	4	12	200	150	350	2	5	6	6
Total	**116**	**90**	**85**	**162**	**4150**	**2050**	**6200**	**41**	**106**	**116**	**46**

* **1 Credit for Participative Learning**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester: I (B.Tech. in Robotics and Artificial Intelligence)											
S.No.	Course Type	Course Code	Course Name	Hours/Week		Credits	Maximum Marks			Total	ESE Duration (Hrs)
							Continuous Assessment		End Semester		
				L	P		TH (I)	PR (I + E)	TH (E)		
1	BSC	26HS03TP0107	Engineering Mathematics I	3	2	4	50	25+25	50	150	3
2	ESC	26EE07TP0106	Basics of Electrical Engineering	2	2	3	50	25+25	50	150	2
3	ESC	26ES03TH0101	Engineering Mechanics	3	0	3	50	0	50	100	3
4	ESC	26ES03TP0102	Engineering Graphics	2	2	3	50	25+25	50	150	2
5	ESC	26ES03TP0103	Fundamentals of Programming	4	2	5	50	25+25	50	150	3
6	AEC/ HSSM	26HS02TP0101	Foundations of Business English	2	2	3	50	25+25	50	150	2
7	AEC/ HSSM	26HS02TH0103-2	Foundational Course in Universal Human Values	1	0	1	50	0	0	50	--
Total				**17**	**10**	**22**	**350**	**250**	**300**	**900**	**15**

I – Internal Evaluation, E - External Evaluation

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester: II (B. Tech. in Robotics and Artificial Intelligence)											
S.No.	**Course Type**	**Course Code**	**Course Name**	**Hours/Week**		**Credits**	**Maximum Marks**			**Total**	**ESE Duration (Hrs)**
							Continuous Assessment		**End Semester**		
				L	**P**		**TH (I)**	**PR (I + E)**	**TH (E)**		
1	BSC	26HS03TH0217	Engineering Mathematics II	3	0	3	50	0	50	100	3
2	BSC	26HS05TP0203	Applied Physics	3	2	4	50	25+25	50	150	3
3	PCC	26ES03TH0201	Theory of Mechanisms and Elasticity	3	0	3	50	0	50	100	3
4	ESC	26ES03TP0202	Digital Logic Design	3	2	4	50	25+25	50	150	3
5	ESC	26ES03TP0203	Data Structures	3	2	4	50	25+25	50	150	3
6	VSEC	26ES03TP0204	Fabrication Practices	1	2	2	50	25+25	--	100	--
7	CCA	26HS02PR0202-2-23	Liberal/Performing Arts	0	2	1	0	25+25	--	50	--
8	CCA	26HS04PR0201	Health-Fitness-Wellbeing	0	2	1	0	25+25	--	50	--
			Total	**16**	**12**	**22**	**300**	**300**	**250**	**850**	**15**

Exit Option

Exit option 1: Award of Certificate in Major after the completion of 44 credits and an additional 8 credits, Finishing School Certificate for a UG Certificate in Robotics and Artificial Intelligence.		L	P	C
Option	Offline certification Course offered by RCOEM-TATA-CIIIT (RTC) or Equivalent as recommended/ approved by the Department	0	0	8
OR				
Option	One Month Internship/ Project at Industry as prescribed by the Industry	0	0	8

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

List of Liberal/Performing Arts Courses

Sr. no.	Course Code	Course Title	Lecture	Practical	Credits	Continuous Evaluation	End Sem Exam/ Internal Evaluation	Total	ESE Duration
1	26HS02PR0102-2	Fundamentals of Indian Classical Dance: Bharatanatyam	0	2	1	25	25	50	--
2	26HS02PR0102-3	Fundamentals of Indian Classical Dance: Kathak	0	2	1	25	25	50	--
3	26HS02PR0102-4	Introduction to Digital Photography	0	2	1	25	25	50	--
4	26HS02PR0102-5	Introduction to Basic Japanese Language	0	2	1	25	25	50	--
5	26HS02PR0102-6	Art of Theatre	0	2	1	25	25	50	--
6	26HS02PR0102-7	Introduction to French Language	0	2	1	25	25	50	--
7	26HS02PR0102-8	Introduction to Spanish Language	0	2	1	25	25	50	--
8	26HS02PR0102-9	Art of Painting	0	2	1	25	25	50	--
9	26HS02PR0102-10	Art of Drawing	0	2	1	25	25	50	--
10	26HS02PR0102-11	Nature Camp	0	2	1	25	25	50	--
11	26HS02PR0102-12	Developing Self-awareness	0	2	1	25	25	50	--
12	26HS02PR0102-13	Art of Poetry	0	2	1	25	25	50	--
13	26HS02PR0102-14	Creative and Content Writing	0	2	1	25	25	50	--
14	26HS02PR0102-15	Science of life through Bhagwad Gita	0	2	1	25	25	50	--

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

15	26HS02PR0102-16	Sanskrit Sambhashan-Spoken Sanskrit	0	2	1	25	25	50	--
16	26HS02PR0102-17	Kirtan Kala	0	2	1	25	25	50	--
17	26HS02PR0102-18	Introduction to German Language and Culture	0	2	1	25	25	50	--
18	26HS04PR0202-19	Adventure Sports	0	2	1	25	25	50	--
19	26HS04PR0202-20	Introduction to Défense Forces & Obstacle Training	0	2	1	25	25	50	--
20	26HS04PR0202-21	First Aid & Disaster Management	0	2	1	25	25	50	--
21	26HS04PR0202-22	Basic Nutritional Course	0	2	1	25	25	50	--
22	26HS04PR0202-23	Stress Management Through Yoga &Meditation	0	2	1	25	25	50	--

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester: III (B. Tech. in Robotics and Artificial Intelligence)											
S.No.	**Course Type**	**Course Code**	**Course Name**	**Hours / Week**		**Credits**	**Maximum Marks**			**Total**	**ESE Duration (Hrs)**
							Continuous Assessment		**End Semester**		
				L	**P**		**TH (I)**	**PR (I + E)**	**TH (E)**		
1	BSC	26HS03TH0303	Probability and Statistics	3	0	3	50	0	50	100	3
2	PCC	26ES03TH0301	Fundamentals of Robotics	3	0	3	50	0	50	100	3
3	PCC	26ES03TP0302	Mechatronics	2	2	3	50	25+25	50	150	2
4	PCC	26ES03TP0303	Microcontrollers and Interfacing	3	2	4	50	25+25	50	150	3
5	PCC	26ES03TP0304	Programming with Python	2	2	3	50	25+25	0	100	-
6	AEC	26ES03PR0405	Design Thinking	0	2	1	0	50	0	50	--
7	OE	26ESOEC03TH0306	Open Elective-I/ MOOC	2	0	2	50	0	50	100	2
8	MDM	26ES03TH0307	MDM-I	3	0	3	50	0	50	100	3
9	VEC	26HS01TP0301	Environmental Science	1	2	2	50	25+25	0	100	
Total				**19**	**10**	**24**	**400**	**200**	**300**	**900**	**16**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester: IV (B. Tech. Robotics and Artificial Intelligence)											
S.No.	**Course Type**	**Course Code**	**Course Name**	**Hours / Week**		**Credits**	**Maximum Marks**			**Total**	**ESE Duration (Hrs)**
							Continuous Assessment		**End Semester**		
				L	**P**		**TH (I)**	**PR (I + E)**	**TH (E)**		
1	PCC	26ES03TP0401	Kinematics and Dynamics of Robot	3	2	4	50	25+25	50	150	3
2	PCC	26ES03TP0402	Control Systems Engineering	3	2	4	50	25+25	50	150	3
3	PCC	26ES03TP0403	Artificial Intelligence	3	2	4	50	25+25	50	150	3
4	CEP/FP	26ES03PR0404	Mini Project-I	0	2	1	0	25+25	0	50	--
5	AEC	26ES03PR0405	Prompt Engineering	0	2	1	0	25+25	0	50	--
6	OE	26ESOEC03TH0406	Open Elective-II/ MOOC	2	0	2	50	0	50	100	2
7	MDM	26ES03TH0407	MDM-II	3	0	3	50	0	50	100	3
8	AEC	26ES03AECPR0408	Algorithmic Problem Solving-I	0	2	1	0	25+25	0	50	--
9	Audit*	26HS04PR0401	Self-Défense & Indian Martial Art	0	2	0	--	--	--	--	--
Total Courses				14	12 + 2*	20	300	250	250	800	14

Exit Option *** Audit course**

Exit option 2: Award of UG Diploma in Robotics and AI in Major after the completion of 88 credits and an additional 8 credits, Finishing School for a UG Diploma in Robotics and Artificial Intelligence.		L	P	C
Option	Offline certification Course offered by RCOEM-TATA-CIIIT (RTC) or Equivalent as recommended/ approved by the Department	0	0	8
OR				
Option	One Month Internship/ Project at Industry as prescribed by the Industry	0	0	8

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester: V (B. Tech. in Robotics and Artificial Intelligence)											
S. No.	**Course Type**	**Course Code**	**Course Name**	**Hours / Week**		**Credits**	**Maximum Marks**			**Total**	**ESE Duration (Hrs)**
							Continuous Assessment		**End Semester**		
				L	P		**TH (I)**	**PR (I + E)**	**TH (E)**		
1	PCC	26ES03TP0501	Machine Learning	3	2	4	50	25+25	50	150	3
2	PCC	26ES03TP0502	Industrial Hydraulics and Pneumatics	3	2	4	50	25+25	50	150	3
3	PCC	26ES03TP0503	Industrial Internet of Things	2	2	3	50	25+25	50	150	2
4	PSE	26ES03TH0504	Program Specific Elective- I	3	0	3	50	0	50	100	3
5	CEP/FP	26ES03PR0505	Mini Project II	0	2	1		25+25	0	50	--
6	OE	26ESOEC03TH0506	Open Elective-III/ MOOC	2	0	2	50	0	50	100	2
7	MDM	26ES03TH0507	MDM-III	3	0	3	50	0	50	100	3
8	PCC	26ES03PR0508	Robot Operating System	0	2	1		25+25	0	50	--
9	AEC	26HS05TP0501	Business Communication	1	2	2	50	25+25	0	100	--
Total				**17**	**12**	**23**	**350**	**300**	**300**	**950**	**16**

Program Specific Electives (PSE) Courses

Sem	**PSE**	**Track 1** **Robotics**	**Track 2** **Data Science and Analytics**	**Track 3** **Smart Manufacturing**	**Track 4** **Systems Engineering and Analytics**
V	I	26ES03TH0504-1 Bio-Inspired Robotics	26ES03TH0504-2 Database Design and Management	26ES03TH0504-3 Computer Aided Design	26ES03TH0504-4 Work System Design

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester: VI (B. Tech. in Robotics and Artificial Intelligence)											
S. No.	**Course Type**	**Course Code**	**Course Name**	**Hours / Week**		**Credits**	**Maximum Marks**			**Total**	**ESE Duration (Hrs)**
							Continuous Assessment		**End Semester**		
				L	**P**		**TH (I)**	**PR (I + E)**	**TH (E)**		
1	PCC	26ES03TH0601	Robot Safety, Maintenance and Standards	2	0	2	50	0	50	100	2
2	PCC	26ES03TP0602	Robotic Vision System	3	2	4	50	25+25	50	150	3
3	PCC	26ES03TP0603	Deep Learning	3	2	4	50	25+25	50	150	3
4	PCC	26ES03TH0604	Mobile Robotics	2	0	2	50	0	50	100	2
5	AEC	26ESAEC03PR0605	Algorithmic Problem Solving-II	0	2	1	0	25+25	0	50	-
6	PSE	26ES03TH0606	Program Specific Elective- II	3	0	3	50	0	50	100	3
7	MDM	26ES03TH0607	MDM-IV	3	0	3	50	0	50	100	3
8	Project	26ES03PR0608	Project-I	0	4	2	0	25+25	0	50	
Total				**16**	**10**	**21**	**300**	**200**	**300**	**800**	**16**

*** Students with CGPA 7.5 and above can opt for one-year full time internship after completion of 6th Semester.**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Program Specific Electives (PSE) Courses

Sem	PSE	Track 1 Robotics	Track 2 Data Science and Analytics	Track 3 Smart Manufacturing	Track 4 Systems Engineering and Analytics
VI	II	26ES03TH0606-1 Drone Technology and UAV Systems	26ES03TH0606-2 Data Exploration and Visualization	26ES03TH0606-3 3-D Printing Technology	26ES03TH0606-4 Facilities Planning and Design

Exit Option

Exit option 3: Award of B.Voc. (Engg.) in Robotics and AI in Major after the completion of 132 credits and an additional 8 credits, Finishing School for a B.Voc. (Engg.) in Robotics and AI.		L	P	C
Option	Offline certification Course offered by RCOEM-TATA-CIIIT (RTC) or Equivalent as recommended/ approved by the Department	0	0	8
OR				
Option	One Month Internship/ Project at Industry as prescribed by the Industry	0	0	8

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester: VII (B. Tech. Robotics and Artificial Intelligence)											
S. No	**Course Type**	**Course Code**	**Course Name**	**Hours / Week**		**Credits**	**Maximum Marks**			**Total**	**ESE Duration (Hrs)**
							Continuous Assessment		**End Semester**		
				L	**P**		**TH (I)**	**PR (I + E)**	**TH (E)**		
1	PCC	26ES03TP0701	Mechanical Design of Robotic System	2	2	3	50	25+25	50	150	2
2	PCC	26ES03TP0702	Agentic AI	2	2	3	50	25+25	50	150	2
3	Project	26ES03PR0703	Project-II	0	8	4	0	50+50	0	100	-
4	PCC	26ES03PR0704	Comprehensive Viva	0	2	1	0	25+25	0	50	
5	PSE	26ES03TH0705	Program Specific Elective III	3	0	3	50	0	50	100	3
6	PSE	26ES03TH0706	Program Specific Elective IV	3	0	3	50	0	50	100	3
7	CCA	26ES03PR0707	Participative Learning*	-	-	1					
8	Audit	26ES03PR0708	Internship Evaluation			SF/ USF	-	-	-	-	-
Total				**10**	**14**	**18**	**200**	**250**	**200**	**650**	**10**

*** Student will earn 1 credit against participative learning till VI semester.**

Sem	**PSE**	**Track 1 Robotics**	**Track 2 Data Science and Analytics**	**Track 3 Smart Manufacturing**	**Track 4 Systems Engineering and Analytics**
VII	III	26ES03TH0705-1 Swarm Robotics	26ES03TH0705-2 Data Engineering	26ES03TH0705-3 Computer Integrated Manufacturing System	26ES03TH0705-4 Operation Research

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

VII	IV	26ES03TH0706-1 Cognitive Robotics	26ES03TH0706-2 Data Privacy	26ES03TH0706-3 Sustainability and Green Manufacturing	26ES03TH0706-4 Human Factors Engineering

Semester: VIII (B. Tech. in Robotics and Artificial Intelligence)											
S. No.	**Course Type**	**Course Code**	**Course Name**	**Hours/Week**		**Credits**	**Maximum Marks**			**Total**	**ESE Duration (Hrs)**
							Continuous Assessment		**End Semester**		
				L	**P**		**TH**	**PR**	**TH/PR**		
1	PCC	26ES03TH0801	Project Management	3	0	3	50	0	50	100	3
2	PCC	26ES03TH0802	Research Methodology	2	0	2	50	0	50	100	2
3	Project	26ES03PR0803	Project-III	0	12	6	0	50	50	100	-
4	IKS	26HS02TH0804	Foundational Literature of Indian Civilization	1	0	1	50	0	0	50	-
			Total	**6**	**12**	**12**	**150**	**50**	**150**	**350**	**5**
OR											
5	Project	26ES03PR0804	Full Semester Industry Internship	0	24	12		**175**	**175 (PR)**	**350**	
OR											
6	Project	26ES03PR0805	Research Internship	0	24	12		**175**	**175 (PR)**	**350**	
OR											
7	Project	26ES03PR0806	TBI Internship	0	24	12		**175**	**175 (PR)**	**350**	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

One Year Internship

Semester: VII and VIII (B. Tech. in Robotics and Artificial Intelligence)											
S. No.	**Course Type**	**Course Code**	**Course Name**	**Hours/Week**		**Credits**	**Maximum Marks**			**Total**	**ESE Duration (Hrs)**
				L	**P**		**Continuous Assessment**		**End Semester**		
							TH	**PR**	**TH**		
One Year Internship Phase-I											
1	Project	26ES03PR0709	Industry Internship Phase-I			12					
2	MOOC	26ES03PR0710	MOOC-I			3					3
3	MOOC	26ES03PR0711	MOOC-II			3					3
Total						**18**					**6**
One Year Internship Phase-II											
1	Project	26ES03PR0807	Industry Internship Phase-II			12					

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Program Specific Electives (PSE) Courses

Sem	PSE		Track 1 Robotics	Track 2 Data Science and Analytics	Track 3 Smart Manufacturing	Track 4 Systems Engineering and Analytics
V	I	Course Code	26ES03TH0504-1	26ES03TH0504-2	26ES03TH0504-3	26ES03TH0504-4
		Course Name	Bio-Inspired Robotics	Database Design and Management	Computer Aided Design	Work System Design
VI	II	Course Code	26ES03TH0606-1	26ES03TH0606-2	26ES03TH0606-3	26ES03TH0606-4
		Course Name	Drone Technology and UAV Systems	Data Exploration and Visualization	3-D Printing Technology	Facilities Planning and Design
VII	III	Course Code	26ES03TH0705-1	26ES03TH0705-2	26ES03TH0705-3	26ES03TH0705-4
		Course Name	Swarm Robotics	Data Engineering	Computer Integrated Manufacturing System	Operation Research
VII	IV	Course Code	26ES03TH0706-1	26ES03TH0706-2	26ES03TH0706-3	26ES03TH0706-4
		Course Name	Cognitive Robotics	Data Privacy	Sustainability and Green Manufacturing	Human Factors Engineering

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Open Elective- MOOCS for Coursera										
SN	Sem	Course Code	Course Name	Hours/week		Credit	Maximum Marks			ESE Duration Exam
				L	P		Cont. Evaluation	End Sem Exam	Total	
1	III	26ESOE04TH0306	Cyber Security in Manufacturing (22 Hour) Industry 4.0 and its impact on manufacturing sector (20 Hour)	2	0	2	50	50	100	2
2	IV	26ESOE04TH0406	Six Sigma Principles (13 Hour) Supply Chain Management and Analytics (34 Hour)	2	0	2	50	50	100	2
3	V	26ESOE04TH0506	Major Engineering Projects: Governance, Risk and Scope (24 Hours) Financing and Initiating Major Engineering Projects (21 Hours)	2	0	2	50	50	100	2
Total				6	0	6	150	150	300	6

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Honors Scheme: B. Tech. in Robotics and Artificial Intelligence

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26ES03HT0301	Field & Service Robot	3	0	3	50	50	100	3
2	IV	26ES03HT0401	Advanced sensors & Actuators	3	0	3	50	50	100	3
3	V	26ES03HT0501	Mobile and Micro Robotics	4	0	4	50	50	100	3
4	VI	26ES03HT0601	Multi-Robot Systems and Swarm Intelligence	4	0	4	50	50	100	3
5	VII	26ES03HP0701	Project	0	8	4	50	50	100	3
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

Minors Scheme: B. Tech. in Robotics and Artificial Intelligence (Offer to other Departments)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26ES03MT0301	Introduction to Robotics	3	0	3	50	50	100	3
2	IV	26ES03MT0401	Field and Service Robot	3	0	3	50	50	100	3
3	V	26ES03MT0501	Industrial Automation	4	0	4	50	50	100	3
4	VI	26ES03MT0601	Robot Safety, Maintenance and Standards	4	0	4	50	50	100	3

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

5	VII	26ES03MP0701	Project	0	8	4	50	50	100	3
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

Multi-Disciplinary Minor (MDM): Track-l: Defense Technology (Offered to other Departments)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26ES03TH0307-1	Defense Platforms	3	0	3	50	50	100	3
2	IV	26ES03TH0407-1	Warfare system	3	0	3	50	50	100	3
3	V	26ES03TH0507-1	Weapon Systems	3	0	3	50	50	100	3
4	VI	26ES03TH0607-1	Self-Defense & Protection system	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Track-II: Robotics (Offered to other Departments)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26ES03TH0307-2	Fundamentals of Robotics	3	0	3	50	50	100	3
2	IV	26ES03TH0407-2	Kinematics of Robots	3	0	3	50	50	100	3
3	V	26ES03TH0507-2	Mobile Robotics	3	0	3	50	50	100	3
4	VI	26ES03TH0607-2	Drone Technology	3	0	3	50	50	100	3

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Track-III: AI Modelling and Simulation (Offered to CSE Departments)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26ES03TH0307-3	Foundations of AI Modelling	3	0	3	50	50	100	3
2	IV	26ES03TH0407-3	Machine Learning for Simulation	3	0	3	50	50	100	3
3	V	26ES03TH0507-3	Advanced Simulation Techniques	3	0	3	50	50	100	3
4	VI	26ES03TH0607-3	AI-Driven Simulation in Practice	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Embedded Systems and IoT (Offered by ECE dept. to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26EE05TH0306-1	Sensors for IoT	3	0	3	50	50	100	3
2	IV	26EE05TH0408-1	Microcontrollers and IoT Applications	3	0	3	50	50	100	3
3	V	26EE05TH0507-1	IoT System Architecture	3	0	3	50	50	100	3

4	VI	26EE05TH0608-1	Use Cases of IoT	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Mobile Communication (Offered by ECE dept. to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26EE05TH0306-2	Fundamentals of Communication	3	0	3	50	50	100	3
2	IV	26EE05TH0408-2	Cellular Communication	3	0	3	50	50	100	3
3	V	26EE05TH0507-2	LTE Technologies	3	0	3	50	50	100	3
4	VI	26EE05TH0608-2	5G and 6G Systems	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): IoT for Environmental Sustainability (Offered by ECS to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26EE01TH0305-1	Introduction to IoT system Design	3	0	3	50	50	100	3
2	IV	26EE01TH0405-1	Programming for Environmental IoT	3	0	3	50	50	100	3

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

3	V	26EE01TH0505-1	IoT Privacy and Security	3	0	3	50	50	100	3
4	VI	26EE01TH0505-1	Use cases of Environmental IoT	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Integrated Circuit Design (IC design) (Offered by ECS to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26EE01TH0305-2	Basics of Chip Design using Verilog HDL	3	0	3	50	50	100	3
2	IV	26EE01TH0405-2	MIPS Processor Design and Testing	3	0	3	50	50	100	3
3	V	26EE01TH0505-2	Chip Verification using System Verilog	3	0	3	50	50	100	3
4	VI	26EE01TH0605-2	VLSI Physical Design	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM) offered by CSE: Web Development (Offered to B. Tech. Robotics and AI students)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	24CS01TH0305-1	Introduction to Web Development	3	0	3	50	50	100	3
2	IV	24CS01TH0407-1	Front End Development	3	0	3	50	50	100	3

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

3	V	24CS01TH0507-1	Backend Technologies	3	0	3	50	50	100	3
4	VI	24CS01TH0605-1	Cloud Technologies	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Cloud Computing (Offered by CSE to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26CS01TH0305-3	Introduction to Cloud Computing + Google Cloud Foundation Certificate	3	0	3	50	50	100	3
2	IV	26CS01TH0407-3	Data Analytics + Google Cloud Data Analytics Certificate	3	0	3	50	50	100	3
3	V	26CS01TH0507-3	Cloud Engineering +Google Cloud Engineer Certificate	3	0	3	50	50	100	3
4	VI	26CS01TH0605-3	Cloud Security Fundamentals + Google Cloud Cyber Security Certificate	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Cyber Security (Offered by CSE to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

1	III	26CS01TH0305-4	Fundamentals of Network Security	3	0	3	50	50	100	3
2	IV	26CS01TH0407-4	Applied Cyber Defence	3	0	3	50	50	100	3
3	V	26CS01TH0507-4	Modern Cloud Security Architecture	3	0	3	50	50	100	3
4	VI	26CS01TH0605-4	Digital Forensics	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Basics of Nuclear Systems (Offered by EE to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	Chemistry	Nuclear Concepts-I	3	0	3	50	50	100	3
2	IV	Physics	Nuclear Concepts-II	3	0	3	50	50	100	3
3	V	Electrical	Basics of Nuclear Measurements	3	0	3	50	50	100	3
4	VI	Physics	Nuclear Security and Safeguards	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Project Management (Offered by MBA to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26MT04TH0307	Introduction to Engineering Project Management	3	0	3	50	50	100	3

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

2	IV	26MT04TH0407	Project Planning, Scheduling, and Cost Control	3	0	3	50	50	100	3
3	V	26MT04TH0507	Engineering Project Risk, Quality, and Leadership	3	0	3	50	50	100	3
4	VI	26MT04TH0607	Advanced Project Management & Capstone for Engineers	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Manufacturing Systems and Productivity Engineering (Offered by ME to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26ES04TH0307	Basics of Mechanical Engineering	3	0	3	50	50	100	3
2	IV	26ES04TH0407	Manufacturing Engineering	3	0	3	50	50	100	3
3	V	26ES04TH0507	Productivity Improvement Techniques	3	0	3	50	50	100	3
4	VI	26ES04TH0607	Smart Manufacturing and Industry 4.0	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Civil Engineering for Sustainable Development (Offered by Civil Engg. to B. Tech. Robotics and AI)

Sr.				Hours/week	Credits	Maximum marks	ESE

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

No.	Sem	Course Code	Course Title	L	P		Continuous Evaluation	End Sem Exam	Total	Duration (Hrs)
1	III	26ES01TH0305	Fundamentals of Civil Infrastructure and Construction	3	0	3	50	50	100	3
2	IV	26ES01TH0404	Construction Materials and Technology	3	0	3	50	50	100	3
3	V	26ES01TH0506	Green Building Construction and Environmental Systems	3	0	3	50	50	100	3
4	VI	26ES01TH0607	Building Construction Methods and Management	3	0	3	50	50	100	3
			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Multi-Disciplinary Minor (MDM): Renewable Energy and E-mobility (Offered by Electrical Engg. to B. Tech. ME)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous	End Sem Exam	Total	
1	III	26EE07TH0309	Introduction to Renewable Energy Sources	3	0	3	50	50	100	3
2	IV	26EE07TH0409	EV Architecture and Components	3	0	3	50	50	100	3
3	V	26EE07TH0509	Energy Storage Systems in E-Mobility	3	0	3	50	50	100	3
4	VI	26EE07TH0609	Autonomous Vehicle	3	0	3	50	50	100	3

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

			Total	**12**	**0**	**12**	**200**	**200**	**400**	**12**

Minor: e-Mobility (BEST) (Offered by Electrical Engg. to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	II	Bridge Course	Foundation EV Mobility				50			
2	III		Battery Pack Design and BMS	3	0	3	50	50	100	3
3	IV		EV Charger Development and Testing	3	0	3	50	50	100	3
4	V		Motor Design Drive Testing	4	0	4	50	50	100	3
5	VI		Vehicle Testing	4	0	4	50	50	100	3
6	VII		Project	0	8	4	50	50	100	3
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

Bajaj Engineering Skills Training (BEST)

Minor: Nuclear Engineering Systems (Offered by Electrical Engg. to B. Tech. Robotics and AI)

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III		Nuclear Fundamentals -I	3	0	3	50	50	100	3
2	IV		Nuclear Fundamentals -II	3	0	3	50	50	100	3
3	V		Nuclear Measurements and Instrumentations	4	0	4	50	50	100	3
4	VI		Nuclear Power Plant	4	0	4	50	50	100	3
5	VII		Project	0	8	4	50	50	100	3
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

Minor: Mechanical Systems and Technology (Offered by ME to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26ES04MT0301	Computer-Aided Design	3	0	3	50	50	100	3
2	IV	26ES04MT0401	Digital manufacturing	3	0	3	50	50	100	3
3	V	26ES04MT0501	Renewable Energy Resources	4	0	4	50	50	100	3
4	VI	26ES04MT0601	Operation Research	4	0	4	50	50	100	3
5	VII	26ES04MP0701	Project	0	8	4	50	50	100	3
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

Minor: IOT (Offered by ECS to B. Tech. Robotics and AI)

Sr.				Hours/week		C r	Maximum marks			ESE

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

No.	Sem	Course Code	Course Title	L	P		Continuous Evaluation	End Sem Exam	Total	Duration (Hrs)
1	III	26EE10MT0301	IoT Fundamentals	3	0	3	50	50	100	3
2	IV	26EE10MT0401	Sensor Interfacing with Arduino and ESP8266	3	0	3	50	50	100	3
3	V	26EE10MT0501	Cloud Computing Using Raspberry Pi	4	0	4	50	50	100	3
4	VI	26EE10MT0601	Data Management and Analytics for IoT	4	0	4	50	50	100	3
5	VII	26EE10MP0701	Project	0	8	4	50	50	100	3
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

Minor: (Offered by CSE to B. Tech. Robotics and AI)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26CS01MT0301	Programming for Problem Solving	3	0	3	50	50	100	3
2	IV	26CS01MT0401	Tools & Techniques of Artificial Intelligence	3	0	3	50	50	100	3
3	V	26CS01MT0501	Exploratory Data Analysis	4	0	4	50	50	100	3
4	VI	26CS01MT0601	Fundamentals of Machine Learning	4	0	4	50	50	100	3
5	VII	26CS01MP0701	Project	0	8	4	50	50	100	3
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

Minor: (Offered by ECE to B. Tech. Robotics and AI)

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26EE05MT0301	Fundamentals of Communication Engineering	3	0	3	50	50	100	3
2	IV	26EE05MT0401	Sensors for Intelligent Instrumentation	3	0	3	50	50	100	3
3	V	26EE05MT0501	IoT for Industrial Application	4	0	4	50	50	100	3
4	VI	26EE05MT0601	Future Generation Networks	4	0	4	50	50	100	3
5	VII	26EE05MP0701	Project	0	8	4	50	50	100	3
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

Minor: (Offered by Civil Engg to B. Tech. Robotics and AI students)

Sr. No.	Sem	Course Code	Course Title	Hours/week		Credits	Maximum marks			ESE Duration (Hrs)
				L	P		Continuous Evaluation	End Sem Exam	Total	
1	III	26ES01MT0301	Sustainable Engineering	3	0	3	50	50	100	3
2	IV	26ES01MT0401	Disaster Management	3	0	3	50	50	100	3
3	V	26ES01MT0501	Engineering Ethics and Professional Practice	3	0	3	50	50	100	3
4	V	26ES01MP0501	Engineering Ethics and Professional Practice Lab	0	2	1	25	25	50	--
5	VI	26ES01MT0601	Basics of Civil Engineering	3	0	3	50	50	100	3
6	VI	26ES01MP0601	Basics of Civil Engineering Lab	0	2	1	25	25	50	--
7	VII	26ES01MT0701	Project	0	8	4	0	0	0	0
			Total	**14**	**8**	**18**	**250**	**250**	**500**	**18**

School of Engineering Sciences

Department of Mechanical Engineering

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B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

2026-27

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

Semester-I

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester I					
Course Code	**Course Title**				**Category**
26HS03TP0107	**Engineering Mathematics I**				**BSC**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
3	**2**	**1**	**50+50**	**50**	**04**

Prerequisite: Students should possess basic knowledge of Mathematics, including algebra, trigonometry, and elementary calculus and basic knowledge of computer.

Course Objectives:

The objective of this course is to develop a strong foundation in differential equations, statistics, probability, and differential calculus, with a focus on their applications in Mechanical and Robotics &AI Engineering. The course integrates theoretical concepts with computational lab-based experiments to enhance students' ability to model, analyze, and solve engineering problems using mathematical and simulation tools.

Course Outcomes:

On successful completion of the course, the students will able to:

1. Solve and analyze first-order ordinary differential equations and apply them to model engineering problems using computational tools.
2. Formulate and solve higher-order differential equations using analytical techniques and interpret their applications through graphical models.
3. Analyze and interpret engineering data using curve fitting, regression, and correlation techniques to identify patterns and relationships.
4. Apply differential calculus methods to solve engineering problems and use computational tools to model and optimize systems involving several variables.
5. Construct and solve partial differential equations related to engineering boundary value problems and simulate their behavior using computational visualization techniques.
6. Implement fundamental matrix operations to simulate and interpret applications in fields such as image processing, computer graphics.

UNIT I: First order ordinary differential equations	**7 Hours**

Exact, linear and Bernoulli's equations, Euler's equations, Equations of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type, Applications of First order Differential Equations.

UNIT II: Ordinary differential equations of higher orders	**7 Hours**

Second order linear differential equations with constant and variable coefficients, method of variation of parameters, Cauchy-Euler equation. Applications of Higher order Differential Equations.

UNIT III: Statistics	**6 Hours**

Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves, correlation and regression – Rank correlation, Multiple regression and correlation and its application in Engineering

UNIT IV: Differential Calculus	**8 Hours**

Taylor's and Maclaurin's series expansions, radius of curvature (Cartesian form), evolutes and involutes, Limit and continuity of functions of several variables and their partial derivatives, Eulers Theorem, chain rule, total derivative, Jacobians, Maxima, minima and saddle points; Method of Lagrange multipliers.

Unit V: Partial Differential Equations	**8 Hours**

Introduction to PDE, solution of homogeneous PDE, solution of PDE with separation of variables, boundary value problems: vibrations of a string, heat equation, potential equation, vibrations of circular membranes.

Experiments:

Exp. No.	**Name of Experiments**	**Mapped COs**
1	To use mathematical software as an advance calculator	**CO1**
2	Graphical Representation of 2D Functions Relevant to Engineering Models	**CO1, CO2, CO3**
3	3D Plotting Techniques for Visualizing ODE-related Engineering Models	**CO1, CO2, CO3**
4	Analyzing Data Trends through Curve Fitting Techniques	**CO3**
5	Visualization and Interpretation of Differential Equation Solutions.	**CO1, CO2, CO5**
6	Differential Calculus Techniques for Modelling Engineering behaviour	**CO4**
7	Applied optimization (Maxima, minima and Gradient descent method)	**CO4**
8	Matrix Computations with various Applications	**CO6**

Textbooks

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

References:

1. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary
2. Value Problems, 9th Edition, Wiley India, 2009
3. A text book of Applied Mathematics Volume I & II, by P. N. Wartikar and J. N. Wartikar, Pune VidhyarthiGrihaPrakashan, Pune-411030 (India).

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester I					
Course Code	**Course Title**				**Category**
26EE07TP0106	**Basics of Electrical Engineering**				**ESC**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
2	**2**	**2**	**50+50**	**50**	**3**

Prerequisite:

Course Objectives:
The objective of this course is to provide mechanical engineering students with a comprehensive understanding of electrical and electronics principles and their application in electromechanical systems. Additionally, the course will explore various case studies to demonstrate the real-world applications of these concepts in industries such as automation, electric vehicles, and medical devices.

Course Outcomes: On successful completion of the module students will be able to:
1. Explain the basics of Electrical systems and various components.
2. Identify the various components in Electro-mechanical systems.
3. Classify the types of power converters as per the applications.
4. Select the battery for specific application.

UNIT I: INTRODUCTION TO ELECTRICAL SYSTEM — **7 Hours**

DC Circuits: Electrical circuit elements (R, L and C), voltage and current sources, Kirchhoff's current and voltage laws, analysis of simple circuits with DC excitation.
AC Circuits: Representation of sinusoidal wave forms, peak and RMS values. Concept of Impedance, Power, Energy. Introduction to 3-phase systems

UNIT II: INTRODUCTION TO POWER CONVERTERS — **7 Hours**

Basic schematic introduction to power converters, Types of Power converter, AC-DC, DC-DC, DC-AC converters, applications

UNIT III: ELECTRICAL MACHINES — **8 Hours**

Introduction to DC motors
Single Phase Transformer: Construction, principle of operation, EMF Equation. Regulation and Efficiency of a Transformer.
Three Phase Induction Motor: Construction and Principle of Operation, Slip and Torque, Speed Characteristics.
Stepper motor: Construction, working principle and modes of operation

UNIT IV: ELECTROMECHANICAL SYSTEMS — **8 Hours**

Introduction to electromechanical systems: Basics of electric motors, actuators, and sensors, Design considerations for integrating electrical and mechanical components, Applications of power electronics in mechanical systems. Selection and sizing of motors for mechanical systems, Motor control techniques and applications.

TEXT BOOKS:

1. D. P. Kothari and I. J. Nagrath, “Basic Electrical Engineering”, Tata McGraw Hill, 2010.
2. Electrical Technology: B. L. Thereja, S. Chand Publications.

3. Electrical & Electronic Instruments & Measurement by A. K. Sawhney, Dhanpat Rai and Co. 19th Edition, 2015.
4. Mechatronics: Principles, Concepts and Applications, Mahalik N. P., Tata McGraw Hill

REFERENCE BOOKS:

1. D. C. Kulshreshtha, "Basic Electrical Engineering", McGrawHill,2009.
2. L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
3. Basic Electrical Engineering: S.B. Bodkhe, N. M. Deshkar, P. P. H. Pvt. Ltd.
4. Electronic Instrumentation & Measurement Technique by W. D. Cooper & A. D. Helfrick, Prentice Hall, 3rd revised Edition, 1985.

Course Outcomes: On successful completion of the module students will be able to:

1. Perform experiments on basis DC and AC circuits and make valid conclusions from observed results.
2. Study the operation of DC-DC converters.
3. To reverse the direction of rotation of a dc shunt motor and control it's speed by different methods.
4. Calculate the energy bill and verify the same with that provided by the utility for a specific installation and specific period.
5. Write effective reports based on observations and conclusions.

List of Experiments:

1. To verify Kirchhoff's laws of DC circuits.
2. To verify Kirchhoff's laws for RLC series circuits.
3. To verify Kirchhoff's laws for RLC parallel circuits.
4. To study DC – DC Buck converter.
5. To study DC – DC Boost converter.
6. To study battery charging.
7. Study of actuators and sensors for electro-mechanical systems.
8. To calculation and verification of energy bill of a house.
9. To reverse the direction of rotation of a dc shunt motor and control it's speed by different methods.
10. To measure power in DC circuit using shunt and voltage divider circuit.
11. To study the charging/ discharging characteristics of super capacitor.
12. Open-ended experiments.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TH0101	Engineering Mechanics				ESC
Contact Hours per Week			CA	FE	Credits
L	P	S			
3	0	1	50	50	03

Prerequisite: Students should possess basic knowledge of Mathematics, including algebra, trigonometry, and elementary calculus, along with an understanding of Physics fundamentals such as force, motion, and Newton's laws. They should also be familiar with vector operations like addition and subtraction, and have an elementary understanding of units and measurements.

Course Objectives:

After completing this course, students will be able to:

1. Develop a strong foundation in force systems, equilibrium, and vector mechanics for engineering applications.
2. Understand and analyse frictional forces and mechanical properties such as centroid and moment of inertia.
3. Apply principles of kinematics and kinetics to study motion of particles.
4. Analyse mechanical systems using work-energy and impulse-momentum principles.
5. Understand and solve problems related to motion and dynamics of rigid bodies in engineering systems.

Course Outcomes:

After successful completion of the course, students will be able to:

1. Apply concepts of force systems, equilibrium, and free body diagrams (FBD) to analyse engineering problems including trusses and structures.
2. Evaluate frictional forces and compute centroid, centre of gravity, and moment of inertia for simple and composite bodies.
3. Analyse motion of particles using kinematic and kinetic principles including Newton's laws and projectile motion.
4. Apply work-energy and impulse-momentum principles to solve problems involving particle motion and systems.
5. Analyse kinematics and kinetics of rigid bodies, including rotation, rolling motion, and general plane motion.

UNIT I: Basics of Mechanics & Force Systems — **8 Hours**

Introduction and need of Engineering Mechanics, Units of Measurement, Force Vectors, Vector Addition of Forces, Equilibrium of a Particle, Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams (FBD), Equations of Equilibrium of Coplanar Systems and Spatial Systems; Static Indeterminacy.

Introduction to Trusses: Structural Analysis of Simple Trusses by joint and section method. Introduction to space trusses, frames.

UNIT II: Friction and Properties of Surfaces & Solids — **8 Hours**

Friction: Basics of friction, Application of friction phenomenon, ladder friction, wedge friction, rolling resistance.

Properties of Surfaces & Solids: Centroid and Centre of Gravity covering, Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia.

UNIT III: Dynamics of Particle	**8 Hours**

Kinematics of a Particle: Introduction to kinematics**,** Rectilinear motion, General Curvilinear Motion, Two-dimensional motion with constant acceleration, Uniform circular motion, Tangential and normal acceleration, Projectile motion.

Kinetics of a Particle: Newton's Second Law of Motion, D'Alembert Principle, Motion of connected bodies (block, pulleys, etc) with and without friction, linear and angular momentum.

UNIT IV: Work-Energy and Impulse-Momentum Principle	**8 Hours**

Work-Energy Principle: The Work of a Force, Principle of Work and Energy for translation, Work-Energy applied to particle motion and connected system and fixed axis rotation, Power and Efficiency, Conservation of Energy.

Impulse-Momentum Principle: Principle of Linear Impulse and Momentum, Angular Momentum, Relation between Moment of a Force and Angular Momentum, Principle of Angular Impulse and Momentum, Principle of Linear Impulse and Momentum for a System of Particles

Unit V: Dynamics of Rigid Body	**8 Hours**

Kinematics of a Rigid Body: Introduction, Types of rigid body motion: translation, rotation about fixed axis, general plane Motion.

Kinetics of rigid body: Introduction, Newton's Second Law of Motion for rotational motion, Equation of translational motion, Equation of rotational motion Fixed-axis rotation, Rolling Bodies, General Plane Motion.

TEXT BOOKS:

1. R. C. Hibbler, Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
2. F. L. Singer, Engineering Mechanics, Statics & Dynamics, BS Publications

REFERENCE BOOKS:

1. Irving H. Shames, Engineering Mechanics – Statics and Dynamics, Pearson Educations, Forth edition, 2003.
2. Beer and Johnson, Vector Mechanics for Engineers, Vol.1 "Statics" and Vol.2 "Dynamics, McGraw Hill International Edition, 1995.
3. S.S. Bhavikatti, Engineering Mechanics, New Age Publications

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0102	**Engineering Graphics**				ESC
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
2	2	2	50+50	50	3

Prerequisite: Nil

Course Objectives:

The objective of the course is to prepare the students:

1. To develop the ability of visualization of different objects through technical drawings.
2. To acquire computer drafting skills for communication of concepts, ideas in the design of engineering products.

Course outcomes

At the end of this course students will be able to:

1. Draw and interpret technical drawings
2. Convert 2-D to 3-D drawing and vice versa.
3. Draw the projection of points and lines located in different quadrants.
4. Develop the solid surface for sheet metal working
5. Use & demonstrate drafting package.

UNIT I: Introduction to Engineering Drawing and Engineering Curves	**5 Hrs.**

Principles of Engineering Graphics and their significance, usage of drawing instruments, Lettering and dimensioning, Engineering Curves - Conic sections, Cycloid and Involute etc.

UNIT II: Orthographic Projections	**6 Hrs.**

Orthographic Projections: Theory of Projections, Concept of Projection, and First & Third angle projection methods. Conversion of given 3-dimensional view to 2-dimensional representation.

UNIT III: Projections of Lines and Planes	**6 Hrs.**

Projections of Lines and Planes: Projections of lines (line inclined to both planes),

Projections of planes (inclined to both the planes), Concept of auxiliary plane method for

projections of the plane.

UNIT IV: Sections of Solids and Development of Surfaces	**7 Hrs.**

Sections of Solids and Development of Surfaces: Projection of solids, Theory of sectioning, sections of prism, pyramid, cylinder and cone, Development of lateral surfaces of solids, Real-world applications of surface development.

UNIT V: Isometric Projections	**6 Hrs.**
Isometric Projections: Principles of Isometric projection - Isometric Scale, Isometric View, and Conversion of Orthographic views to Isometric Views / Projection.	

Text Books:

1. Agarwal B & Agarwal C.M. Engineering Graphics, Tata McGraw Hill Publications.
2. Engineering Drawing by N.D. Bhatt, Charotar Publishing House Pvt. Ltd.
3. Engineering Drawing with an Introduction to AutoCAD" by D. A. Jolhe Tata McGraw Hill Publications
4. Engineering Drawing by R.K. Dhawan, S. Chand Publications
5. Engineering Drawing by K.L. Narayana & P. Kannaiah, SciTech Publication

Reference Books:

1. AutoCAD 14 for Engineering Drawing by P. Nageshwara Rao, Tata McGraw Hill Publications.
2. A text book of Engineering Drawing by P.S. Gill, S.K. Kataria & sons, Delhi.
3. Engineering Drawing and Computer Graphics by M. B. Shah & B.C. Rana, Pearson Education.

Course Code: 26ES04TP0102	**Course: Engineering Graphics Lab**

Introduction to Computer Aided Drawing:

Introduction, Drawing Instruments and their uses, relevant BIS conventions and standards.
Lettering, line conventions, dimensioning, material conventions and free hand practicing.
Computer screen, layout of the software, standard tool bar / menu and description of most commonly used tool bars, and navigational tools.
Co-ordinate system and reference planes HP, VP, RPP & LPP of 2D/3D environment. Selection of drawing sheet size and scale.
Commands and creation of lines, coordinate points, axes, poly-lines, square, rectangle, Polygon, splines, circles, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz., tangency, parallelism, inclination and perpendicularity.
Practical's to be performed from the list as below

List of sheets

1 Engineering Curves
2 Orthographic Projection
3 Projection of Straight Lines and Planes
4 Section of solids and Development of surfaces
5 Isometric projection

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES04TP0103	FUNDAMENTALS OF PROGRAMMING				PCC
Contact Hours per Week			CA	ESE	Credits
L	P	S			
04	02	02	50 (T) + 50 (P)	50 (T)	04 + 01 = 05

Prerequisite: Nil

Course Objectives

The course aims to:

- Develop fundamental programming skills using C and C++ languages
- Understand basic data structures and algorithms
- Learn structured and object-oriented programming concepts
- Build problem-solving capabilities through programming exercises
- Apply learned concepts to solve real-world coding problems

Course Outcomes (COs)

Upon successful completion of the course, students will be able to:

CO1: Apply fundamental C programming concepts including data types, operators, control structures, and functions to develop modular programs that solve computational problems.

CO2: Analyze computational problems and design efficient solutions using arrays, strings, pointers, and structures with appropriate memory management and algorithmic techniques.

CO3: Evaluate programming solutions by analyzing algorithm complexity, memory management strategies, and determining optimal approaches for searching, sorting, and data manipulation.

CO4: Design and develop object-oriented programs in C++ using classes, constructors, destructors, inheritance, and operator overloading for code reusability and functionality.

UNIT 1: Fundamentals of C Programming (10 hours)

1.1 INTRODUCTION TO PROGRAMMING AND C LANGUAGE (1 HOUR)

- Evolution and features of C language
- Structure of a C program
- Compilation and execution process
- Writing, compiling, and running a simple C program

1.2 DATA TYPES AND VARIABLES (2 HOURS)

- Basic data types: int, float, double, char

- Type modifiers: signed, unsigned, short, long
- Variable declaration and initialization
- Constants and literals
- Input/output functions: printf(), scanf()

1.3 OPERATORS AND EXPRESSIONS (2 HOURS)

- Arithmetic operators
- Relational and logical operators
- Assignment operators
- Increment and decrement operators
- Bitwise operators
- Conditional (ternary) operator
- Operator precedence and associativity

1.4 CONTROL STRUCTURES (5 HOURS)

- Decision making: if, if-else, nested if-else, else-if ladder
- Switch-case statement
- Looping constructs: for, while, do-while
- Nested loops
- Break, continue, and goto statements

UNIT 2: Functions and Storage Classes (10 hours)

2.1 FUNCTIONS (4 HOURS)

- Introduction to functions and modular programming
- Function declaration, definition, and calling
- Function arguments and return values
- Call by value and call by reference
- Function prototypes
- Library functions vs. user-defined functions

2.2 RECURSION (3 HOURS)

- Concept of recursion
- Recursive vs. iterative approach
- Applications: factorial, Fibonacci series, Tower of Hanoi
- Advantages and limitations of recursion

2.3 STORAGE CLASSES (2 HOURS)

- Automatic (auto) storage class
- External (extern) storage class
- Static storage class
- Register storage class
- Scope and lifetime of variables

2.4 ARRAYS (1 HOUR)

- Introduction to arrays
- One-dimensional arrays: declaration, initialization, and accessing
- Basic array operations

UNIT 3: ADVANCED TOPICS (10 HOURS)

3.1 MULTIDIMENSIONAL ARRAYS (3 HOURS)

- Two-dimensional arrays
- Matrix operations: addition, multiplication, transpose
- Multidimensional arrays
- Passing arrays to functions

3.2 STRINGS (2 HOURS)

- String declaration and initialization
- String input/output functions
- String manipulation functions: strlen(), strcpy(), strcat(), strcmp()
- Array of strings

3.3 POINTERS (3 HOURS)

- Introduction to pointers and memory addressing
- Pointer declaration and initialization
- Pointer operators: * (indirection) and & (address-of)
- Pointer arithmetic
- Pointers and arrays
- Pointers and functions
- Pointer to pointer

3.4 STRUCTURES (2 HOURS)

- Introduction to structures
- Structure declaration and initialization
- Accessing structure members
- Array of structures
- Structures and functions
- Nested structures
- Pointers to structures

UNIT 4: INTRODUCTION TO C++ AND OBJECT-ORIENTED PROGRAMMING (9 HOURS)

4.1 BASICS OF C++ (2 HOURS)

- Evolution of C++ and comparison with C
- Object-oriented programming concepts: encapsulation, abstraction, polymorphism, inheritance
- Structure of a C++ program
- Basic input/output: cin, cout, cerr
- Namespace and scope resolution operator
- Reference variables and const keyword
- Inline functions and function overloading

4.2 CLASSES AND OBJECTS (3 HOURS)

- Introduction to classes and objects
- Class declaration and definition
- Access specifiers: private, public, protected
- Member functions and data members
- Creating and accessing objects

- Constructors: default, parameterized, copy constructor
- Destructors
- Static members and friend functions
- this pointer

4.3 OPERATOR OVERLOADING (2 HOURS)

- Concept of operator overloading
- Overloading unary operators
- Overloading binary operators
- Rules and restrictions for operator overloading
- Type conversion in C++

4.4 INHERITANCE (2 HOURS)

- Concept of inheritance and code reusability
- Types of inheritance: single, multiple, multilevel, hierarchical, hybrid
- Base class and derived class
- Access control in inheritance
- Constructor and destructor in derived classes
- Virtual base classes and Function overriding

UNIT 5: Problem-Solving and Practice (10 hours)

THIS UNIT FOCUSES ON APPLYING THE CONCEPTS LEARNED IN UNITS 1-4 THROUGH HANDS-ON PROBLEM-SOLVING ON THE LEETCODE PLATFORM. STUDENTS WILL WORK THROUGH 20 CAREFULLY SELECTED PROBLEMS THAT PROGRESSIVELY BUILD PROBLEM-SOLVING SKILLS AND REINFORCE PROGRAMMING CONCEPTS

LEARNING OBJECTIVES:

- Apply data structures (arrays, strings, pointers, structures) to solve real problems
- Implement algorithms using control structures and functions
- Develop recursive solutions and understand their applications
- Practice object-oriented programming principles in C++
- Analyze time and space complexity of solutions
- Build debugging and testing skills

Textbooks

1. Kernighan, B. W., & Ritchie, D. M. (1988). The C Programming Language (2nd ed.). Prentice Hall.
2. Balagurusamy, E. (2019). Programming in ANSI C (8th ed.). McGraw Hill Education.
3. Kanetkar, Y. (2020). Let Us C (17th ed.). BPB Publications.
4. Balagurusamy, E. (2017). Object-Oriented Programming with C++ (7th ed.). McGraw Hill Education.
5. Lafore, R. (2002). Object-Oriented Programming in C++ (4th ed.). Pearson Education.
6. Stroustrup, B. (2013). The C++ Programming Language (4th ed.). Addison-Wesley.

Online Resources for Problem Solving:

1. LeetCode Platform - https://leetcode.com/
2. GeeksforGeeks - Data Structures and Algorithms tutorials

3. HackerRank - Programming challenges and competitions

Reference Books

Gottfried, B. S. (2010). Programming with C (3rd ed.). Tata McGraw Hill.
Forouzan, B. A., &Gilberg, R. F. (2007). Computer Science: A Structured Programming Approach Using C (3rd ed.). Cengage Learning.
Deitel, P., &Deitel, H. (2015). C: How to Program (8th ed.). Pearson.

Deitel, P., &Deitel, H. (2016). C++ How to Program (10th ed.). Pearson.
Lippman, S. B., Lajoie, J., & Moo, B. E. (2012). C++ Primer (5th ed.). Addison-Wesley.
Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2009). Introduction to Algorithms (3rd ed.). MIT Press.

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Course Code	Course Title				Category
26HS02TP0101	**Foundations of Business English**				**AEC**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
02	02	04	50 + 50	50	**03**

Prerequisites: NA

Course Objectives:

The course aims to develop foundational communication skills required for academic and professional success by enhancing students' competence in grammar, vocabulary, speaking, listening, reading, and writing. It also seeks to familiarize learners with workplace communication practices and emerging AI-assisted communication tools, thereby improving their employability and readiness for professional contexts.

Course Outcomes:

After successful completion of the course, students will be able to:

CO1: Apply and demonstrate active listening techniques and grammatical rules to construct accurate, coherent, and contextually appropriate communication.

CO2: Analyse and apply verbal aptitude strategies, business vocabulary, and reading comprehension techniques to interpret written communication effectively.

CO3: Demonstrate and adapt public speaking techniques and professional etiquette to deliver structured and audience-centric oral communication in workplace scenarios.

CO4: Evaluate and apply employability communication strategies by actively participating in group discussions, mock interviews, and résumé-building exercises to meet professional standards.

CO5: Create and justify professional documents using appropriate formats and ethically integrate AI-assisted tools to enhance clarity, accuracy, and effectiveness in communication.

UNIT I: Listening Comprehension and Remedial Grammar	**05 Hrs.**
Listening Comprehension: Active listening, Reasons for poor listening, Barriers to effective listening, Traits of a good listener, Note-making. Remedial Grammar: Common Errors in Indian English, Subject-verb agreement, Tenses	

UNIT II: Structural Communication and Reading Comprehension Verbal Aptitude: Para-jumbles, Analogies, Sentence completion, Syllogisms Business Vocabulary: Use of power verbs, power adjectives and power adverbs, Common technical affixes, Avoiding corporate jargons Reading Comprehension: Types and Strategies	**05 Hrs.**
UNIT III: Speaking Skills Public Speaking: Mechanics of Public Speaking, Five-C model of storytelling (audience-centric), principles of effective introductions and welcome addresses, and questioning techniques. Professional Oral Communication: Meetings, seeking and giving feedback Professional Etiquette: greetings, introductions, politeness strategies, telephone and virtual communication	**05 Hrs.**
UNIT IV: Communication for Employment Group Discussions: concepts, types, roles, and evaluation parameters Résumé Building: structure, content, and formatting techniques Introduction to Interview Skills: types of interviews, commonly asked questions, and response strategies	**05 Hrs.**
UNIT V: Professional Communication Principles of professional document design Academic and professional email writing (format, tone, etiquette) Instruction writing (clarity, sequencing, audience awareness) Statement of Purpose (SOP): structure and content Introduction to AI-assisted communication (AI prompts and applications) and Ethical considerations in the use of AI in professional communication	**05 Hrs.**

Foundations of Business English Lab

Syllabus

List of Practical
Computer Assisted + Activity Based Language Learning
Practical 1: Everyday Situations: Conversations and Dialogues – Listening Skills
Practical 2: Reading Skills
Practical 3: Everyday Situations: Conversations and Dialogues – Speaking Skills
Practical 4: Pronunciation, Intonation, Stress, and Rhythm

Activity Based Language Learning
Practical 5: Public Speaking
Practical 6: Presentation Skills: Orientation
Practical 7: Presentation Skills: Mock

Practical 8: Group Discussions: Practice
Practical 9: Group Discussions: Mock

Text Books:

1. *Communication Skills*. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
2. *Practical English Usage.* Michael Swan. OUP. 1995.
3. *Remedial English Grammar*. F.T. Wood. Macmillan.2007
4. *On Writing Well.* William Zinsser. Harper Resource Book. 2001
5. *Study Writing.* Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
6. *The AI Prompt Handbook for Business Writing: 50+ Prompts for Professionals, Managers & Entrepreneurs (The AI Prompt Handbook Series)*, Maxwell Striling, 2026

Reference Book:

1. *Communication Skills*. Sanjay Kumar and Pushp Lata. Oxford University Press.
2. *Practical English Usage.* Michael Swan. OUP. 1995.

Course Code	Course Title				Category
26HS02TH0103-2	**Foundation course in Universal Human Values**				VEC
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
1	-	1	25+25	-	**1**

Prerequisites: NA

Course Objectives:

After completing this course, students will be able to:
To help the students in holistic development and maintaining harmony at all the levels of a human being, i.e. individual, family, society and nature/existence.

Course Outcomes:

After successful completion of the course, students will be able to:

CO1: Understand value education in life and implement self-exploration.

CO2: Create an in-depth understanding of harmony within a human being.

CO3: Understand and implement values to maintain harmony in a family.

CO4: Understand and implement values to maintain harmony in a society

CO5: Understand and implement values to maintain harmony in nature/existence and develop a holistic perspective of life.

UNIT I: Course Introduction - Understanding Value Education	**04 Hrs.**

1.Meaning of Value Education

2.Need of value education, guidelines and content of value education.

3.Exploring our aspirations and concerns: Self-exploration (Content and process of selfexploration) 4. Basic human aspirations: Continuous happiness and prosperity 5. Role of UHV; Strengthening of self-reflection.	
UNIT II: Understanding Harmony in Human Being	**03 Hrs.**
1.Harmony of the self and the body. a. Understanding human being as a co-existence of the sentient 'I' and the material 'Body' b. Understanding the needs of Self ('I') and 'Body'. c. Understanding the activities of Self ('I') and 'Body' d. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer). 2. Programs to ensure Sanyam and Health	
UNIT III: Understanding Harmony in the Family: Harmony in Human-Human relationship	**03 Hrs.**
1. Understanding values in human-human relationship: a. Trust as the foundational value of a relationship and respect in a family b. Ensuring health of family and friends by implementing values c. Understanding the meaning of trust; d. Difference between intention and competence e. Understanding the meaning of respect, f. Difference between respect and differentiation	
UNIT IV: Understanding harmony in the society: Harmony in Human-Human relationship	**02 Hrs.**
1. Understanding harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) 2. Visualizing a universal harmonious order in society: Undivided Society, Universal Order-from family to world family.	
UNIT V: Understanding Harmony in Nature and Existence:	**03 Hrs.**
1. Understanding harmony in Nature 2. Interconnectedness and mutual fulfilment among the four orders of Nature	

3. Holistic perception of harmony at all the levels of existence

Text Books:

1. A Foundation Course in Human Values and Professional Ethics, R.R Gaur, R Athana, G.P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019, ISBN 948-93-87034-47-1
2. A Textbook on Professional Ethics and Human Values by R S Naagarazan, New Age International Private Limited; First edition, 2020.

Reference Book:

1. Human Values, A.N. Tripathi, Human Values, New Age Intl. Publishers, New Delhi, 2004.
2. Human Values and Professional Ethics by Gurpreet Singh Uppal, 2015.
3. Values and Ethics in Profession by Prof. Mazumdar, Everest Publishing House; 3rd Edition, 2013.
4. Human Values and Professional Ethics by Jayshree Suresh, B S Raghavan, S Chand; Fourth edition, 2003.
5. https://fdp-si.aicte-india.org/UHV-II_Lectures_PPTs.php
6. dp-si.aicte-india.org/UHV-II%20Practice%20Sessions.php
7. https://fdp-si.aicte-india.org/UHV-II%20Class%20Note.php
8. B L Bajpai, 2004, Indian Ethos and Modern Management, New Royal Book Co., Lucknow. Reprinted 2008
9. PL Dhar, RR Gaur, 1990, Science and Humanism, Commonwealth Purblishers.
10. Sussan George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991
11. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and HarperCollins, USA
12. Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, 1972, limits to Growth, Club of Rome's Report, Universe Books.
13. Subhas Palekar, 2000, How to practice Natural Farming, Pracheen(Vaidik) Krishi Tantra Shodh, Amravati.
14. A Nagraj, 1998, Jeevan Vidya ek Parichay, Divya Path Sansthan, Amarkantak.
15. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

Semester-II

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS03TH0217	Engineering Mathematics IIProbabi				BSC
Contact Hours per Week			CA	FE	Credits
L	P	S			
3	0	1	50	50	03

Prerequisite: Students should possess basic knowledge of Mathematics, including algebra, trigonometry, and elementary calculus.

Course Objectives:

The objective of this course is to familiarize the prospective engineers with techniques in Calculus and multivariate analysis. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

Course Outcomes: On successful completion of the course, the students will able to:

1. Interpret the solutions of system of linear equations and use the concepts of Eigen values, Eigen vectors to find diagonalization of matrices.
2. Evaluate definite and improper integrals using Beta, Gamma functions, and trace the Cartesian curves.
3. Solve multiple integration by change of order, change of variable methods and apply it to find area, volume, mass and center of gravity.
4. Interpret the geometrical meaning of gradient, curl, divergence
5. Perform line, surface and volume integrals of vector-valued functions.

UNIT I: Linear Algebra — **7 Hours**

Rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Eigenvalues and eigenvectors; Cayley Hamilton Theorem; Diagonalization of matrices; Orthogonal transformation and quadratic to canonical forms, Introduction to n-dimensional space, Singular value decomposition and its application in reducing the dimensionality of images and data .

UNIT II: Integral Calculus — **7Hours**

Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Tracing of curves(Cartesian form)

UNIT III: Multiple Integral — **8 Hours**

Multiple Integration: Double and triple integrals (Cartesian and polar), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: area, mass and volume by double integration, Center of mass and Gravity (basic concepts).

UNIT IV: Vector Calculus (Differentiation) — **7 Hours**

Scalar point function, Vector point function, vector differentiation, gradient, divergence and curl, directional derivatives with their physical interpretations, solenoidal and irrotational motions, Scalar

potential function.

Unit V: Vector Calculus (Integration)	**7 Hours**

Vector integration: Line integrals, work done, conservative fields, surface integrals and volume integrals, Stoke's theorem, Gauss divergence theorem, Green's theorem and their simple applications.

Topics for self-learning

Rolle's theorem, Mean value theorems, Indeterminate forms, Applications of definite integrals to evaluate perimeter, area, surface areas and volumes of revolutions.

Textbooks

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition,2000.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

References

1. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
2. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
3. P. N. Wartikar and J. N. Wartikar, A text book of Applied Mathematics Volume I & II, Pune Vidhyarthi Griha Prakashan, Pune-411030 (India).

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS05TP0203	Applied Physics				BSC
Contact Hours per Week			CA	FE	Credits
L	P	S			
03	02	02	50+50	50	4

Prerequisites:

Course Objectives:
After completing this course, students will be able to:

1. To develop ability to correlate basic physics principles involved in Robotic operations.
2. To help to improve fundamental robotic operations.

Course Outcomes:
After successful completion of the course, students will be able to:

1. Use LASER beam and its various applications.
2. Apply knowledge of Ultrasonics for robotic operations.
3. Study and apply fundamental principles of electromagnetics to Mechanical Engineering.
4. Apply fundamental knowledge of fluid dynamics to underwater and arial robotics. Explore various sensing mechanisms pertaining to various Robotic operations.
5. Prepare for measurements used in various experiments and analyze errors involved in the measurements and prepare reports.
6. Explore various methods for finding wavelength of light, magnetic field intensity, speed of waves.

UNIT I: Laser Physics	**08 Hrs.**

Basics of Laser light emission: Spontaneous and stimulated emission of radiations, thermal equilibrium, condition for light amplification, population inversion, pumping schemes, optical resonator, He-Ne Laser/ Ruby Laser.
Laser beam characteristics: Monochromaticity, Coherence, Directionality, Focusibility, Intensity, Beam divergence and applications thereof.

UNIT II: Ultrasonics	**08 Hrs.**

Basics of Ultrasonics: Ultrasonic waves, production and detection of ultrasonic waves, piezoelectric effect, properties and types of ultrasonic waves, measurement of ultrasonic velocity in liquids.
Applications of Ultrasonic waves: in the measurement of elastic constants in liquids, application of ultrasonic waves in drilling, welding, soldering, in non-destructive testing of various materials, in generating 3D maps.

UNIT III: Electromagnetism	**08 Hrs.**

Magneto-statics: Lorenz Force, Biot-Savart and Ampere's Laws and their applications, Magnetic vector potential, force and torque on a magnetic dipole, and applications.
Electrodynamics: Ohms law, motional emf, Faraday's law, Lenz's law, Mutual induction, energy storage in magnetic fields, Maxwell's equations and applications.

UNIT IV: Aeronautics Physics	**08 Hrs.**
Fluid mechanics for underwater and aerial robotics. Buoyancy, floatation, stability of floating body. Hydro-dynamics: Boundary layer concepts of drag, lift, its real-world applications to smart skies, mobile accelerometers, parachutes, helicopters, numerical on drag & lift forces, parachute design.	
UNIT V: Sensors and Actuators	**08 Hrs.**
Design and working principles of Sensors. Various types of Sensors requited for Robotics: Strain, pressure, ultrasonic, piezoelectric, chemical, thermal, optical, electrical, etc, as required for various types of detection.	

TEXT BOOKS:

1. Engineering Electromagnetics, Sixth Edition, William H. Hayt, John A. Buck, McGraw-Hill Higher Education, 2001.
2. Applied Physics by S. Jain, G. G. Sahasrabudhe and S. M. Pande, Universities Press 2013.

REFERENCE BOOKS:

1. Ultrasonics: Fundamentals, Technologies, and Applications, Dale Ensminger, Leonard J. J. Bond. 2011, CRC press, 2011.
2. Fundamentals of Aerodynamics 5ED (SIE), McGraw Hill Education, 2017.
3. Fundamentals of Sensors for Engineering and Science (English, Paperback, Dunn Patrick F.), CRC Press, Taylor & Francis Inc, 2011.
4. Engineering Physics by M.N. Avadhanulu and Kshirsagar S. Chand Publication, 2014.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES04TH0201	Theory of Mechanisms & Elasticity				PCC
Contact Hours per Week			CA	FE	Credits
L	P	S			
03	00	01	50	50	3

Prerequisites:
Students should have:
1. Knowledge of **Mathematics**, including algebra, trigonometry, and elementary calculus.
2. Knowledge of Engineering Mechanics course.

Course Objectives:
After completing this course, students will be able to:
1. Understand the fundamentals of mechanisms and machines, including kinematic pairs, chains, and degrees of freedom.
2. Analyze and apply inversions of mechanisms in practical engineering systems and machines.
3. Study the design and motion characteristics of cams and followers used in automated systems.
4. Develop knowledge of stress, strain, and material behavior under different loading conditions.
5. Apply concepts of compound stresses, strain energy, and failure analysis in engineering applications.

Course Outcomes:
After successful completion of the course, students will be able to:
CO1: Explain and analyze mechanisms, kinematic chains, and degrees of freedom using standard criteria such as Kutzbach's and Gruebler's equations.
CO2: Apply the concept of inversions of mechanisms to evaluate and design common machine elements like four-bar chains and slider-crank mechanisms.
CO3: Analyze cam-follower systems, including motion profiles, displacement diagrams, and pressure angle considerations.
CO4; Evaluate simple stresses and strains, including deformation, thermal effects, and stress-strain relationships in materials.
CO5; Analyze compound stress systems and strain energy concepts, including principal stresses, Mohr's circle, and energy methods for impact loading

UNIT I: Basics of Mechanisms and Machines	**08 Hrs.**

Basics of Mechanisms and Machines: Basic concept of mechanism, link, kinematics pairs, kinematics chain, mechanism, machine, simple & compound chain, Degree of freedom, Kutzbach's theory, Grubber's criterion. Harding's notations, Class-I& Class-II mechanisms

UNIT II: Applications of Inversion of Mechanisms	**08 Hrs.**

Inversions and applications of a four-bar chain, single slider crank chain and double slider chain. Limiting positions, Mechanical advantage, Transmission angle, various types of mechanism such as Geneva wheel, Pawl and ratchet mechanism, and mechanism used in various toys, Introduction to Belt drive, Chain drive and gear drives **(7)**

UNIT III: Cams and Followers	**08 Hrs.**

Classification of cams and followers-Terminology and definitions- Displacement diagrams-uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions, and pressure angle and its significance, radial follower and offset followers	
UNIT IV: Concept of simple stresses and strains	**08 Hrs.**
Concept of stress and strain, Types of stresses: Direct and tangential stresses, Types of strains: longitudinal, lateral, volumetric, Simple and modified Hooke's Law and elastic constants (E, G, K, μ) Stress-strain diagram (ductile & brittle materials), Factor of safety, Poisson's ration, Deformation of bars under axial load and due to self-weight, Axial force diagram, Thermal stresses and strains.	
UNIT V: Compound Stresses & Strain and Strain Energy	**08 Hrs.**
Compound Stresses & Strain: Stress on inclined plane, Significance of principal stresses and principal planes, maximum shear stresses, Mohr's circle of stress **Strain energy:** Strain energy and resilience, Proof resilience and modulus of resilience, Strain energy in axial, shear, bending, and torsion, Impact and suddenly applied loads	
TEXT BOOKS: 1. Theory of Machines: S.S. Rattan, Tata McGraw Hill Publishers, 3rd edition onwards 2. Strength of Materials by S.S. Rattan, McGraw-Hills Education (India) Publication, India. *3.* Strength of Materials by S.S. Bhavikatti, Vikas Publishing house, Noida, India.	
REFERENCE BOOKS: 1 Deepak Khemani. A First Course in Artificial Intelligence.McGraw Hill Education (India), 2013. Denis Rothman. Artificial Intelligence by Example, Packt, 2018. 2. Kinematics & Dynamics of Machinery: R.L. Norton Tata McGraw Hill Publishers 3. Mechanism and Machine Theory: J.S. Rao&Rao V. Dukkipati, New Age International 4. Strength of Materials by F.L. Singer, Harper and row Publication. 5. Engineering Mechanics of Solid by Egor P. Popov, Prentice Hall of India Publication.	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0202	Digital Logic Design				ESC
Contact Hours per Week			CA	FE	Credits
L	P	S			
3	2	1	50 +50	50	4

Prerequisite: None.

Course Objectives:
Apply various optimization techniques to minimize digital circuits and design combinational logic circuits.

Course Outcomes: On successful completion of the module students will be able to:
CO1: Explain the fundamentals of digital electronics, number systems, Boolean algebra, logic gates, and simplify combinational logic circuits using Boolean laws and Karnaugh maps.

CO2: Analyze and design combinational logic circuits using multiplexers, demultiplexers, encoders, decoders, code converters, adders, subtractors, and binary arithmetic circuits.

CO3: Describe the operation and timing characteristics of storage elements, latches, and various types of flip-flops, and perform flip-flop conversions for sequential circuit design.

CO4: Design and analyze sequential circuits including synchronous and asynchronous counters, registers, shift registers, ring counters, Johnson counters, sequence generators, sequence detectors, serial adders, and Linear Feedback Shift Registers (LFSRs).

CO5: Design synchronous sequential circuits using Mealy and Moore finite state machine (FSM) models, develop state transition diagrams, and construct Algorithmic State Machine (ASM) charts for digital system implementation.

UNIT I: Introduction to Digital Logic System	**09 Hrs.**
Basics of Digital Electronics: Motivation for digital systems: Number Systems and arithmetic's, Logic and Boolean algebra, logic gates & truth tables, SOP, POS, Minimization of combinational circuits using Karnaugh- maps.	
UNIT II: Circuit Design	**09 Hrs.**
Combinational Circuit Design: Multiplexers, De-multiplexers, Encoders, Decoders, Code Converters, Adders, Subtractor (Half, Full), BCD Adder/ Subtractor, ripple and carry look-ahead addition, Unsigned Multiplier.	
UNIT III: Sequential Circuit Design – I	**9 Hrs.**
Sequential circuit Design-I: Storage elements, Flip-flops and latches: D, T, J/K, S/R flip-flops: level triggered, edge triggered, Master Slave flip-flop, flip flop conversion, timing analysis.	
UNIT IV: Sequential Circuit Design – II	**9 Hrs.**

Sequential circuit Design-II: Design of asynchronous and synchronous counters, Registers & Shift registers, Application of shift register: ring counter, Johnson counter, sequence generator and detector, serial adder; Linear feedback shift register (LFSR)

UNIT V: Synchronous Sequential Circuit Design	**9 Hrs.**

Design of synchronous sequential circuit using Mealy model and Moore model: state transition diagram, algorithm state machine (ASM) chart.

TEXT BOOKS:

1. Donald P. Leach, Albert P. Malvino and GoutamSaha, “Digital Principles & Applications 8e”, McGraw Hill
2. Douglas V. Hall “Microprocessors and Interfacing” Tata McGraw Hill Education Private Limited, 2005

REFERENCE BOOKS:

1. Thomas L Floyd, “Digital Fundamentals 9e”, Pearson
2. M. Morris Mano and Michael D. Ciletti, “Digital Design 5e”, Pearson
3. Taub and Shilling, “Digital Integrated Electronics”, McGraw Hill
4. A. Anand Kumar, “Fundamentals of Digital Circuits” Fourth Edition, PHI
5. Kip R. Irvine, “Assembly Language for x86 Processors” Seventh Edition, Pearson Education

List of Experiments

1. To verify truth table of different logic gates.
2. Design basic logic gates using universal gate and verify its truth table.
3. To verify following Boolean expressions using gates and Multisim software.

a) A+AB+AB
b) AB(C+AC)

4. To implement the following arithmetic circuits using (a) logic gates IC’s and (b) using Multisim software.

a) Full adder
b) Half subtractor

5. Implement the function F = Σm (1,3,5,7,8,9,11,13,15) using 16:1 and 8:1 multiplexer.
6. Verify the truth table of SR, JK, JKMS, T and D flip flop.
7. To study the following functions of Shift register using IC 7495

a) SIPO
b) PIPO
c) PISO
d) SISO

8. Design and verify 2-bit synchronous down counter using S-R flip-flop.
9. Design and verify the functionality of a sequence detector to detect the sequence 1101 using Melay and Moore model and use J-K flop-flop to implement the design.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0203	Data Structures				ESC
Contact Hours per Week			CA	ESE	Credits
L	P	S			
03	02	01	50+50	50	04

Prerequisite: Programming for Problem Solving

Course Objectives:

1. To introduce the basic concepts of data structures and algorithms.
2. To familiarize students with different searching and sorting techniques.
3. To enable students to use appropriate data structure for solving real-world problems

Course Outcomes: On successful completion of the module students will be able to:

CO1: Demonstrate understanding of fundamental data organization concepts, abstract data types (ADT), algorithm design principles, and analyze computational efficiency using asymptotic notations, time complexity, and space complexity.

CO2: Apply linear data structures such as arrays, stacks, and queues to design, implement, and solve problems

CO3: Design and implement linked data structures including singly, doubly, and circular linked lists, and perform various operations such as insertion, deletion, traversal etc.

CO4: Analyze and implement hierarchical and network-based data structures including trees, binary search trees, and graphs for efficient searching, balancing, traversal, and representation of complex relationships.

CO5: Evaluate, compare, and implement various sorting and searching techniques

UNIT I: Data Structures and Algorithm Basics	**08 Hrs.**

Introduction: Elementary data organizations and operations on it. Abstract data types (ADT) and their characteristics.
Algorithms: Characteristics, Asymptotic notations, time and space trade-offs, Analysis of algorithm.
Array ADT: Representations – row-major and column-major form, Implementation of problems using arrays.

UNIT II: Linked List	**08 Hrs.**

Singly Linked Lists (SLL): Creation of SLL, Operations on SLL: Insertion, Deletion, Traversal, reversal, ordering, etc., Linked representation of stacks and queues, Header node linked lists.
Doubly and Circular Linked Lists (DLL and CLL): Creation of Linked list and operations on it.

UNIT III: Stacks and Queues	**08 Hrs.**

Stack ADT: Stack implementation using Linked list, Operations on Stack.
Queue ADT: Queue implementation using Linked list, Circular queue, Operations on queue, introduction to double-ended queues and priority queues.

UNIT IV: Trees and Graphs	**08 Hrs.**

Trees: Terminologies, Binary tree and operations, Binary search tree [BST] and operations.
Introduction to Graphs: Basic terminologies, representation of graphs, graph traversals: depth first search (DFS) and Breadth first search (BFS).

UNIT V: Sorting and Searching	**08 Hrs.**

Sorting: Implementation of Shell, quick, merge, heap, counting sort, performance analysis and comparison.
Searching: Revision of linear search, binary search and complexity analysis of search methods. Hash functions and hash tables, closed and open hashing, randomization methods (division method, mid-square method, folding), collision resolution techniques.

TEXT BOOKS:

1. Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed; Fundamentals of Data Structures in C; Second Edition; Universities Press; 2008.
2. Robert Kruse, C. L. Tondo, Bruce Leung, Sashu Mogalla, Data Structures and Program Design in C; Second Edition; Pearson Education; 2006.
3. Mark Allen Weiss; Data Structures and Algorithm Analysis in C; Second Edition; Pearson Education; 2002.

REFERENCE BOOKS:

1. Reema Thareja, Data Structures using C, Third Edition, Oxford University Press, 2023
2. Narasimha Karumanchi, Data Structures and Algorithms Made Easy: Data Structures and Algorithmic Puzzles Fifth Edition, Career Monk Publications, 2016.
3. The Complete Reference: Herbert Schildt, 4th (any recent) Edition, Tata McGraw Hill

List of Experiments

1. Write a program to perform basic Array operations – insertion, deletion, traversal, searching, and updating elements.
2. Implement matrix representation using row-major and column-major order for two-dimensional arrays.
3. Create and perform operations on Singly Linked List (SLL) – insertion, deletion, traversal, reversal, and sorting.
4. Implement Doubly Linked List (DLL) and Circular Linked List (CLL) with creation and basic operations.
5. Implement Stack using Linked List and perform push, pop, peek, and display operations.
6. Implement Queue using Linked List and perform enqueue, dequeue, and display operations.
7. Implement Circular Queue, Deque, and Priority Queue for different queue applications.
8. Create Binary Tree and Binary Search Tree (BST) and perform insertion, deletion, searching, and tree traversals.
9. Represent Graph using adjacency matrix/list and perform DFS and BFS traversals.
10. Implement Sorting and Searching techniques – Quick Sort, Merge Sort, Heap Sort, Linear Search, Binary Search, and Hashing with collision resolution.

Course Code	**Course Title**			**Category**
26ES03TP0204	**Fabrication Practices**			VSEC
Contact Hours per Week		**CA**	**FE**	**Credits**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

L	P	S			
1	2	1	50 +50		2

Prerequisite: Manufacturing Processes.

Course Objectives:

The objective of the course is to prepare the students:

1. Identify the different manufacturing process for various workshop trades including fitting, carpentry, smithy/foundry and welding, etc.

2. To get acquainted with the knowledge of various machine tools and equipment.

Course outcomes

At the end of this course students will be able to:

1. Understand casting technique for the production of casted components.
2. Identify an appropriate moulding pattern and various carpentry joints.
3. Understand the machining parameters and cutting tool for various machining operations.
4. Distinguishwithhotandcoldworkingmethodforthemanufacturingofmetalcomponents.
5. Understand various fitting joints and sheet metal operations.
6. Apply the knowledge of suitable joining processes to carryout fabrication work.

Foundry and Carpentry	**3 Hrs.**

Introduction to foundries, metal casting, types of sand, introduction to moulding tools & different casting process. Introduction to pattern making for metal casting, different types of carpentry tools, holding devices, different types of carpentry joints.

Metal Cutting	**3 Hrs.**

Fundamentals of metal cutting, Lathe machine specification and operations, metal cutting parameters, single point cutting tool.

Smithy and Forging	**2 Hrs.**

Smithy and forging, hot working and cold working of metals, forging tools like chisels, hammers, types of furnaces.

Fitting	**2 Hrs.**

Fitting operations and associated measuring and marking tools, sheet metal operations. Laser Cuting.

Welding	**2 Hrs.**

Metal joining Process, types of welding, mechanics of welding, soldering and brazing. Robotic welding.

Text Books:

1. Workshop Technology, Volume-I&II, Hajra Choudhary, Media Promoters & Publishers Pvt. Ltd.
2. Manufacturing Technology, Volume-I&II- P.N.Rao, Tata McGraw Hill Pub. Company, New Delhi.

Reference Books:

Manufacturing Science - A.Ghosh & A.K.Malik – East West Press Pvt. Ltd. New Delhi.

Course Code: 26ES03PR0205	**Course: Fabrication Practices Lab**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Objectives:
The Objective of the course:

1. To familiarize with major manufacturing process and required Machine Tools.
2. To get acquainted with and hands on experience on machine tools and equipment.

Course Outcomes:
The expected learning outcome is that the students will be able to:

1. Prepare and mould for casting and perform pattern making.
2. Perform different machining operations on lathe machine and parts fitting job.
3. Apply the knowledge of joining processes to carry out fabrication work.

List of Experiments:
Introduction of tools, equipment, material & process along with demonstration and preparation of simple job using various workshop trades such as:

1. Metal casting and moulding practice
2. Pattern making practice
3. Machining practices
4. Smithy and forging practice
5. Fitting job practice
6. Welding practice

*Case study: To prepare simple model/project using various workshop facilities (Group Activity)

Text Books

1. Workshop Technology, Volume - I & II - By Hajra Choudhary, Media Promoters &Publishers Pvt. Ltd.
2. Manufacturing Technology, Volume - I & II - P.N. Rao, Tata McGraw Hill Pub. Company, New Delhi.
3. Manufacturing Science - A.Ghosh & A.K.Malik – East West Press Pvt. Ltd. New Delhi.

Reference Books

1. Kalpak Jain and Schimd, Manufacturing processes for engineering materials, 5th Edition - Pearson India, 10034.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and System.
3. Production Engineering - P. C. Sharma, S. Chand and Company Ltd., New Delhi.

Course Code	Course Title		Category
26HS02PR0105-1	**Liberal/Performing Art Courses** **Course: Fundamentals of Indian Classical Dance: Bharatnatayam**		**Regular**
Contact Hours per Week	**CA**	**FE**	**Credits**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

L	P	S			
0	**2**	**1**	**25**	**25**	**1**

Prerequisite: None.

Course Objectives:

The course aims to introduce the students to Bharatnatyam, an important element of Indian traditional knowledge system. The course will not only provide the learning and skill to perform this art but would also enhance many mental and physical aspects of the students such as strength, flexibility, discipline, self-confidence, creativity, focus, coordination, etc.

Course Outcomes

On completion of the course, students will be able to achieve the following:
CO1: Understand the importance of dance and Bharatnataym as an Indian dance form
CO2: Develop skills to perform the dance form at its basic level.
CO3: Evaluate their strengths and interest to take bridge course to give Pratham (1st level formal exam of Bharatnatayam).

Syllabus

Practical -1: Orientation in Bharatnatayam
Practical-2: Tattu Adavu till 8, Naatta Adavu 4 Steps, Pakka Adavu 1 step, Metta Adavu 1 Step, Kuditta Metta Adavu 4 Steps,
Practical -3: Practice sessions
Practical-4: Tatta Kuditta Adavu (Metta), Tatta Kuditta Adavu (Metta) 2 Steps, Tirmanam Adavu 3 Steps, Kattu Adav - 3 Steps, Kattu Adav - 3 Steps
Practical-5: Practice sessions
Practical-6: Tiramanam (front) 3 Steps, Repeat of Tiramanam (Overhead) 3 Steps,
Practical-7: practice sessions
Practical – 8: final practice sessions and performances.

Recommended reading

1. Introduction to Bharata's Natyasastra, Adya Rangacharya, 2011
2. The Natyasastra and the Body in Performance: Essays on the Ancient Text, edited by Sreenath Nair, 2015
3. Bharatanatyam How to ... : A Step-by-step Approach to Learn the Classical Form, Eshwar Jayalakshmi, 2011

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS02PR0105-2	**Liberal/Performing Art Courses** **Course: Fundamentals of Indian Classical Dance: Kathak**				**Regular**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course objective

The course aims to introduce the students to Kathak, an important element of Indian traditional knowledge system. The course will not only provide the learning and skill to perform this art but would also enhance many mental and physical aspects of the students such as strength, flexibility, discipline, self-confidence, creativity, focus, coordination, etc.

Course Outcomes

On completion of the course, students will be able to achieve the following:
CO1: Understand the importance of dance and Kathak as an Indian dance form
CO2: Develop skills to perform the dance form at its basic level.
CO3: Evaluate their strengths and interest to take bridge course to give Prarambhik (1st level formal exam of Kathak).

Syllabus

Practical -1: Orientation in Kathak. Correct posture of kathak, Basic Movements and exercise Stepping, Chakkar of 5 count (Bhramari),
Practical -2: practice sessions of practical 1
Practical -3: Hastaks, Hastaks and Steppings, Reciting asamyukta Mudra shloka, Hastak and steppings
Practical -4: practice sessions of practical 3
Practical -5: Todas and Asamyukta hasta mudra shlok, Vandana of Shlok, 2 Todas and Vandana, Ghante Ki Tihai,
Practical -6: practice sessions of practical 5
Practical -7: 2 1 Chakkardar Toda and Ginnti Ki Tihai, 2 Todas and 1 Chakkardar Toda, practice sessions
Practical -8: Final performances.

Recommended reading

1. Kathak Volume1 A "Theoretical & Practical Guide" (Kathak Dance Book), Marami Medhi & Debasish Talukdar, 2022, Anshika Publication (13 September 2022)

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS02PR0105-3	**Liberal/Performing Art Courses** **Course:** Introduction to Digital Photography				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course objective
The course aims to develop basic skills of students in digital photography to lay a foundation for them as a hobby and/or a profession.

Syllabus
Practical 1: Orientation in digital photography: Genres, camera handling and settings
Practical 2: Rules of Composition
Practical 3: Rules of Composition: practice sessions
Practical 4: Understanding Exposure and Art of Pre-Visualization
Practical 5: Rules of Composition and Art of Pre-Visualization: practice sessions
Practical 6: Post Processing Photographs and Portfolio creation
Practical 7: Post Processing Photographs: practice sessions
Practical 8: Portfolio finalization and presentation in selected genre.

Syllabus
Practical -1: Orientation in Kathak. Correct posture of kathak, Basic Movements and exercise Stepping, Chakkar of 5 count (Bhramari),
Practical -2: practice sessions of practical 1
Practical -3: Hastaks, Hastaks and Steppings, Reciting asamyukta Mudra shloka, Hastak and steppings
Practical -4: practice sessions of practical 3
Practical -5: Todas and Asamyukta hasta mudra shlok, Vandana of Shlok, 2 Todas and Vandana, Ghante Ki Tihai,
Practical -6: practice sessions of practical 5
Practical -7: 2 1 Chakkardar Toda and Ginnti Ki Tihai, 2 Todas and 1 Chakkardar Toda, practice sessions
Practical -8: Final performances.

Reference material

1. Scott Kelby (2020) The Digital Photography Book: The Step-by-Step Secrets for how to Make Your Photos Look Like the Pros, Rocky Nook, USA
2. Larry Hall (2014) Digital Photography Guide: From Beginner to Intermediate: A Compilation of Important Information in Digital Photography, Speedy Publishing LLC, Newark
3. J Miotke (2010) Better Photo Basics: The Absolute Beginner's Guide to Taking Photos Like a Pro, AMPHOTO Books, Crown Publishing Group, USA

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS02PR0105-8	**Liberal/Performing Art Courses** **Course: Art of Painting**				**Regular**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course objective

Painting is fundamentally about learning to see, and to transport that vision onto paper through a variety of mark making techniques. This course aims to develop basic skills of students in painting to lay a foundation for them as a hobby and/or a profession.

Course outcome:

At the end of the course the students will be able to achieve the following:

CO1: Become familiar with the basic methods, techniques & tools of painting.

CO2: Train the eye and hand to develop sense of balance, proportion and rhythm.

CO3: Develop the ability to observe and render simple natural forms.

CO4: Enjoy the challenging and nuanced process of painting.

Syllabus

Practical 1: Orientation in Painting tools & basics of lines, shapes, light, shadows and textures

Practical 2: The art of observation - how to see shapes in drawing

Practical 3: Introduction Water color - how to handle water paints

Practical 4: Introduction to acrylic colors - how to handle acrylic paints

Practical 5: Explore layering paint and capturing the quality of light with paint.

Practical 6: Create landscape painting

Practical 7: Create Abstract painting

Practical 8: Paint on Canvas (try to recreate any famous painting)

Reference material

1. Drawing made easy by Navneet Gala; 2015th edition
2. Alla Prima II Everything I Know about Painting--And More by Richard Schmid with Katie Swatland
3. Daily Painting: Paint Small and Often To Become a More Creative, Productive, and Successful Artist by Carol Marine

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS02PR0105-9	**Liberal/Performing Art Courses Course: Art of Drawing**				**Regular**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course objective

Drawing is fundamentally about learning to see, and to transport that vision onto paper through a variety of mark making techniques. This course aims to develop basic skills of students in drawing to lay a foundation for them as a hobby and/or a profession.

Course outcome:

At the end of the course the students will be able to achieve the following:

CO1: Become familiar with the basic methods, techniques & tools of drawing.

CO2: Train the eye and hand to develop sense of balance, proportion and rhythm.

CO3: Develop the ability to observe and render simple natural forms.

CO4: Enjoy the challenging and nuanced process of drawing.

Syllabus

Practical 1: Orientation in Drawing tools & basics of lines, shapes, light, shadows and textures

Practical 2: The art of observation how to see shapes in drawing

Practical 3: One/two-point basic linear perspective

Practical 4: Nature drawing and landscapes

Practical 5: Gestalt principles of visual composition

Practical 6: Figure drawing: structure and proportions of human body

Practical 7: Gesture drawing: expression and compositions of human figures

Practical 8: Memory drawing: an exercise to combine the techniques learnt

Reference material

1. Drawing made easy by Navneet Gala; 2015th edition
2. Perspective Made Easy (Dover Art Instruction) by Ernest R. Norling

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS02PR0105-10	**Liberal/Performing Art Courses** **Course: Nature Camp**				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course Objective: To create an opportunity for the students to develop affinity with nature and thus subsequently impact their ability to contribute towards sustainability of nature.

Course outcome:

After the completion of the course the students will be able to do the following:

CO1: Develop an affinity with nature by observing and understanding it marvels with guidance from experts

CO2: Develop an understanding of the challenges and solutions associated with nature and its conservation.

Course content

In collaboration with the Forest Department and/or a local NGO working in the field of environment conservation, this course would be conducted in 24 hours. Students will be taken to a tiger reserve in Central Indian region or Forest fringe villages or work with an NGO from Central Indian region working on natural resource management. The camps (for 2 days) will cover any one of the following topics as decided by the course coordinator:

1. Awareness about each element of biodiversity (camps on moths, butterflies, birds, other wildlife etc)
2. Environment management (water, forest, wildlife) – practices of Forest Department in managing a tiger reserve, and other aspects of water and forest conservation.
3. Sustainable natural resource management - initiatives by rural communities and local NGOs
4. Man-animal conflict and solutions (socio-economic and technical) – role of local communities and Forest Department
5. Traditional practices in environment conservation – role of local communities and local NGOs

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS02PR0105-11	**Liberal/Performing Art Courses** **Course: Developing Self-awareness**				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course objectives:

The course aims to develop students in their personal as well as professional life by means of graphotherapy, NLP, and Neurobics

Course Outcomes:

On completion of the course, students will be able to achieve the following:

CO1: Gain foundational understanding of graphology and through self-analysis will achieve greater awareness about their strengths and weaknesses & areas for personal growth

CO2: students will be equipped with tools and techniques for continuous self-improvement, using signature analysis and graphotherapy as part of their personal development journey

CO3: understand how to use Neuro Linguistic Programming (NLP) strategies to set and achieve goals effectively, overcoming mental blocks and limiting beliefs.

CO4: Enhance ability to absorb, retain, and recall information, which can benefit academic and professional performance.

Syllabus:

Practical 1: The Power of Handwriting (Handwriting is Brainwriting)

Practical 2: Know yourself through handwriting

Practical 3: The Role of Signature in your life

Practical 4: Graphotherapy to enhance yourself in all ways

Practical 5: Neurolinguistic Programming , S.M.A.R.T Goal

Practical 6: Effective Communication Model, Rapport Building and Anchor

Practical 7: Brain Directives & Linguistic Presuppositions

Practical 8: Neurobics

Course Code	Course Title				Category
26HS02PR0105-12	**Liberal/Performing Art Courses** **Course: Art of Poetry**				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course Outcomes:
To familiarize the students with the art of poetry and develop a sense of appreciation for the art.

At the end of the course the student will be able to achieve the following:
CO1: Understand the origin and development of poetry
CO2: Appreciate the art of poetry in life
CO3: Develop aesthetic sense
CO4: Develop holistic perspective to their personality

Syllabus:
Practical 1: The Power of Handwriting (Handwriting is Brainwriting)
Practical 2: Know yourself through handwriting
Practical 3: The Role of Signature in your life
Practical 4: Graphotherapy to enhance yourself in all ways
Practical 5: Neurolinguistic Programming , S.M.A.R.T Goal
Practical 6: Effective Communication Model, Rapport Building and Anchor
Practical 7: Brain Directives & Linguistic Presuppositions
Practical 8: Neurobics

Reading material

I. The Art of Poetry

1. Fry, S. (2005). The ode less travelled: Unlocking the poetic mind. HarperCollins.
2. Addonizio, K., & Laux, D. (1997). The poet's companion: A guide to the pleasures of writing poetry. W.W. Norton & Company.
3. Lucy, J. (Ed.). (2001). The art of poetry. Penguin Books.

II. Understanding and Interpretation of Poetry

1. Hirsch, E. (1999). How to read a poem: And fall in love with poetry. Harcourt Brace & Company.
2. Pinsky, R. (1998). The sounds of poetry: A brief history. Farrar, Straus and Giroux.
3. Meyer, M. (2005). Poetry: An introduction. Bedford/St. Martin's.

III. Writing Poetry

1. Hugo, R. (1979). The triggering town: Lectures and essays on poetry and writing. W.W. Norton & Company.
2. Bradbury, R. (1990). Zen in the art of writing: Releasing the creative genius within you. Bantam Books.
3. Behn, R., & Twichell, C. (Eds.). (1992). The practice of poetry: Writing exercises from poets who teach. HarperCollins.

Course Code	Course Title				Category
26HS02PR0105-13	Liberal/Performing Art Courses Course: Creative and content writing				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course objective:

The objective of the course is to equip students with comprehensive skills in creative and content writing through experiential learning and real-world applications.

Course outcomes:

On completion of the course, student will be able to achieve the following:

CO1: Understand and apply fundamental concepts and techniques of creative writing.

CO2: Apply storytelling techniques to create engaging narratives.

CO3: Develop and implement effective SEO and digital content strategies

CO4: Create and refine content using various tools and applying diverse writing styles and formats.

CO5: Utilize digital tools to craft multimedia narratives and create a professional portfolio.

Syllabus

Creative Writing

Practical 1: Introduction to Creative and Content Writing

Practical 2: Character and Story Development

Practical 3: Crafting Compelling Narratives

Content Writing

Practical 4: SEO and Digital Content Strategies

Practical 5: Writing for Media

Practical 6: Tools

Content Creation

Practical 7: Digital Storytelling

Practical 8: Creative Portfolio Launch

Course Code	Course Title				Category
26HS02PR0105-14	**Liberal/Performing Art Courses** **Course: Science of life through Bhagwad Gita**				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course Objective

The objective of the course is to seek directions from the Bhagwad Gita to garner life skills for a successful and happy life

Course Outcome

CO1: To understand the methodology to correctly interpret and analysis the scripture

CO2: To understand the application of various teaching of the Bhagwad Gita

CO3: Use meditation and breathing techniques for healthy mind and body.

Syllabus

Practical 1: Introduction to Bhagwad Gita - methodology

Practical 2: Real life application of chapter 1-3

Practical 3: Real life application of chapter 4-6

Practical 4: Real life application of chapter 7-9

Practical 5: Real life application of chapter 10-12

Practical 6: Real life application of chapter 13-15

Practical 7: Real life application of chapter 16-18

Practical 8: Meditation and breathing techniques

Course Code	Course Title				Category
26HS02PR0105-1-1	**Liberal/Performing Art Courses** **Course: Introduction to French Language**				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course Objectives:
To help build a foundation and interest in Spanish language so that the students can pursue the proficiency levels of the language in higher semesters.

Course Outcomes:
On completion of the course, students will be able to achieve the following:

CO1. Demonstrate basic knowledge about Spain, the culture and similarities/differences between India and France
CO2. Learn to use simple language structures in everyday communication.
CO3. Develop ability to write in basic Spanish about themselves and others.
CO4. Develop ability to read and understand beginner level texts in Spanish

Syllabus
Practical-1: Orientation about Spain, the language, and culture
Practical-2: Communication Skills 1: Vocabulary building for everyday conversations
Practical -3: Practice sessions
Practical-4: Reading and writing Skills: Reading and writing simple text in Spanish
Practical-5: Practice sessions
Practical-6: Communication Skills 2: listening comprehension

Practical-7: Practice sessions
Practical-8: Writing Skills: Write basic Spanish and practice
Practical-8: WritingSkills:WritebasicFrenchandpractice

Recommended reading

1. 15-Minute Spanish by Ana Bremon
2. Aula Internacional 1 by Jaime Corpas ,Eva Garcia, Agustin Garmendia.
3. ChicosChicasLibro del Alumno by MaríaÁngeles Palomino

Course Code	Course Title				Category
26HS02PR0105-1-1	**Liberal/Performing Art Courses** **Course: Introduction to French Language**				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	2	1	25	25	**1**

Prerequisite: None.

Course Objectives:
To help build a foundation and interest in the French language so that the students can pursue the proficiency levels of the language in higher semesters.

Course Outcomes:

On completion of the course, students will be able to achieve the following:

CO1. Demonstrate basic knowledge about France, the culture and similarities/differences between India and France.
CO2. Learn to use simple language structures in everyday communication.
CO3. Develop the ability to write in basic French about themselves and others.
CO4. Develop the ability to understand beginner-level texts in French

Syllabus

Practical-1: Orientation about France, the language, and culture

Practical-2: Communication Skills 1: Vocabulary building for everyday conversations

Practical-3: Practice sessions

Practical-4: Reading and writing Skills: Reading and writing simple text in French

Practical-5: Practice sessions

Practical-6: Communication Skills2: listening comprehension

Practical-7: Practice sessions

Practical-8: Writing Skills: Write basic French and practice

Course Code	Course Title				Category
26HS02PR0105-1-1	**Liberal/Performing Art Courses** **Course: Introduction to Basic Japanese Language**				Regular
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**T**	**D/P**			
0	0	2	25	25	**1**

Prerequisite: None.

Course Objectives:

The course aims to develop basic communication skills in the Japanese Language and help develop a basic understanding of Japanese cross-cultural communication.

Course Outcomes: On successful completion of the module, students will be able to:

After completing this course, students will be able to

CO1. Gain a brief understanding of Japan as a country and Japanese culture.
CO2. Developability to use vocabulary required for basic level communication in the Japanese language.
CO3. Able to write and read the first script in the Japanese language.
CO4. Able to frame simple sentences in Japanese to handle everyday conversations
CO5. Able to write in basic Japanese about the topics closely related to the learner.

Syllabus

Practical-1: Orientation about Japan, its language, and its culture

Practical-2: Communication Skills 1: Vocabulary for basic Japanese language

Practical-3: Practice sessions
Practical-4: Writing Skills 1: Reading and writing the first script in Japanese
Practical-5: Practice sessions
Practical-6: Communication Skills 2: framing sentences
Practical-7: Practice sessions
Practical-8: Writing Skills 2: Write basic Japanese and practice

Recommended reading

1. Marugoto Starter (A1) Rikai - Course Book for Communicative Language Competences, by the Japan Foundation, Goyal Publishers &Distributors Pvt. Ltd (ISBN: 9788183078047)
2. Japanese Kana Script Practice Book – Vol. 1 Hiragana, by Ameya Patki, Daiichi Japanese Language Solutions (ISBN: 9788194562900)

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

SEMESTER II					
Course Code	**Course Title**				**Category**
26HS04PR0201	**Health, Fitness & Wellbeing**				**CCA**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
0	**2**	**1**	**25**	**25**	**01**

Aim of the Course: The course aims to foster Health and wellness through Healthy and Active Lifestyle and creating awareness about the fundamentals of Physical Education, Sports, Yoga, Recreation and its effectiveness through practical experiences and hands on activities.

Course Objectives:

1. To impart the students with basic concepts of Sports, Yoga and Recreational activities for health and wellness.
2. To familiarize the students with health-related Exercise and evaluate their Health-related Fitness.
3. To make Overall growth & development with team spirit, social values and leadership qualities among students through various sports, games and Yogic activities.
4. To create Environment for better interaction and recreation among students as neutralizer for stress through various minor and recreational games.

Course Outcomes:

On successful completion of the course, student shall be able to

CO1: (Imitation & Manipulation): Practice and perform general and specific fitness exercises and observe the fundamental skills of Sports, Games and basic Yogic exercises.
CO2: (Precision & Articulation): Demonstrate accuracy in measuring health & skill related fitness components and coordinate with the psychomotor skills to execute fundamental skills of Sports, Games and Yogic Activities.
CO3: (Naturalization): Design personal daily energy requirements and adapt health & fitness conscious habits for sustainable active lifestyle.

UNIT I:	**6 Hours**

- Warm up and Cool Down and Stretching Exercises.
- Calculation of BMI & Resting Pulse Rate.
- General and Specific exercises for strength, Speed, Agility, Cardiovascular Endurance, Flexibility, Coordination.
- Practice of Fundamental Skills of Volleyball, Table Tennis and Chess, etc.
- Knowledge and practice of the Equipment used in a Gymnasium and its application.

UNIT II:	**7Hours**

- Various Fitness Drills: walking, jogging, running, rope skipping, circuit training, interval training, fartlek training. etc.
- Yog: Standing, Sitting, Prone & Supine positions
- Suryanamaskar.
- Overall Wellness: Pranayama, Meditation and Relaxation Techniques.

- Practice of Recreational Games.
- Dietary Habits, Daily Energy Requirements.
- Practice of Fundamental Skills of Basketball, Football, Carrom, etc.
- Health related Physical Fitness Test.

Textbooks/ Reference Books:

- Uppal, A.K. (2023). Fitness, Wellness & Nutrition. New Delhi: Friends Publication.
- Russell, R.P. (1994). Health and Fitness Through Physical Education. USA: Human Kinetics.
- Kumar, Ajith. (1984) Yoga Pravesha. Bengaluru: Rashtrothanna Prakashana.
- Dr. Devinder K. Kansal, A Textbook of Test Evaluation, Accreditation, Measurements and Standards (TEAMS ‘Science)

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

Semester-III

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

SEMESTER III					
Course Code	**Course Title**				**Category**
26HS03TH0303	**Probability & Statistics**				**BSC**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
3	**0**	**1**	**50**	**50**	**03**

Prerequisite: Basics of Probability and Statistics

Course Objectives:

The objective of this course is to expose student to understand the basic importance fundamental principles of probability, including probability distributions, random variables, basic statistical methods used for data analysis, inferential statistics, hypothesis testing, confidence intervals, and regression analysis in Robotics and AI.

Course Outcomes:

On successful completion of the course, student shall be able to

1. Grasp the meaning of discrete and continuous random variables, probability distribution. Interpret the meaning of probabilities derived from distributions. This involves understanding what the calculated probabilities represent in practical terms and drawing conclusions from the results.
2. Compute probabilities and statistical measures using Binomial, Poisson, and Normal distributions.
3. Calculate joint, marginal, and conditional probabilities using joint probability mass functions (PMFs) and joint probability density functions (PDFs).
4. Understand the concept of a sampling distribution and its importance in inferential statistics. Also understand null hypothesis (H0) and alternative hypothesis (H1), significance levels, p-values, and the basic logic behind hypothesis testing.
5. Apply the F-test to determine whether two population variances are significantly different and conduct a Chi-square test to evaluate the association between categorical variables.

UNIT I:	**6 Hours**
Probability spaces, conditional probability, Discrete and continuous random variables, expectation and variance of random variable.	
UNIT II:	**7Hours**
Binomial distribution, Poisson distribution, Normal distribution and their applications, exponential distribution.	
UNIT III:	**7 Hours**
Joint probability function for discrete and continuous random variables, Marginal probability functions, expectation and variance of multivariate random variables, covariance.	
UNIT IV:	**9 Hours**

Small and large sampling, Sampling Distributions, Point and Interval Estimations, Testing of Hypothesis for single mean and proportion for both small and large sample size, testing the means of paired observation

Unit V:	**7 Hours**

Testing of Hypothesis for difference of mean and proportion, Test for ratio of variances, Chi-square test for goodness of fit and independence of attributes

Textbooks:

1. Murray R. Spiegel, Schaum's Outline of Probability and Statistics, McGraw-Hill Education 4th Edition 2012
2. DeGroot, M. H., & Schervish, M. J. (2012). *Probability and statistics* (4th ed.). Addison-Wesley.

Reference Books:

1. MaurtisKaptein, Statistics for data science, An introduction to probability, statistics and Data Analysis, Springer 2022.
2. Jay L Devore,Probability and Statistics for Engineering and sciences, 8th edition, Cenage learning.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code		Course Title				Category
26ES03TH0301		Fundamentals of Robotics				PCC
Contact Hours per Week				CA	ESE	Credits
L	P	S	Total			
03	00		**03**	50	50	03

Prerequisite:

Course Objectives:

1. To introduce the fundamental concepts of robot anatomy, configurations, and workspace.
2. To familiarize students with the working principles of various sensors and actuators used in robotics.
3. To provide an overview of robot control, programming methods, and their role in modern industry.

Course Outcomes: On successful completion of the module students will be able to:
CO1 Explain basic concepts, structure, robot configurations, and classification of robots.
CO2 Explain the working principles of robotic sensors and select suitable sensors for robotic applications.
CO3 Analyze robot drive and actuation systems.
CO4 Develop basic robot programs and control strategies.
CO5 Discuss robotic applications for industrial use.

UNIT I: INTRODUCTION — **07 Hrs.**

Definitions, history of robotics, benefit of robot, need of robot, laws of robotics, robot anatomy, types of robot, coordinate system, work envelope, robot specifications, robot parts and their functions, wrist and orientation.

UNIT II: SENSORS IN ROBOTICS — **08 Hrs.**

Definition of sensors, requirement of sensors, characteristics of sensors, classifications of sensors, **Internal Sensors**: Position sensors (Potentiometers, Encoders, LVDT), Velocity sensors (Tachometer, Hall effect sensor), acceleration sensors, **External Sensors:** Tactile (Touch sensors and force sensors), Proximity (Inductive, capacitive, ultrasonic), Range Sensors (LiDAR and IR sensors).

UNIT III: ROBOT ACTUATION AND DRIVE SYSTEMS — **08 Hrs.**

Definition, factors considered for selecting drive system, actuators, types of actuators: **Electric Drives:** Stepper motors, DC Servo motors, and BLDC motors; selection criteria for torque and speed. **Fluid Power:** Principles of Pneumatic and Hydraulic actuators; applications in industries. Comparison of pneumatic, hydraulic electrical drives. **Transmission Systems:** Gear transmission, Belt drives, Rollers, chains, Links, Linearto-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearings.

UNIT IV: ROBOT CONTROL AND PROGRAMMING — **07 Hrs.**

Open-loop vs. Closed-loop systems; basic concepts of PID control for joint stability, Point-to-Point (PTP) vs. Continuous Path (CP) motion, methods for robot programming**:** Lead-through, textual, and Off-line programming defining a program, Method of defining position in space, Motion interpolation, Basic programming commands in workcell control (wait, signal and delay commands), Branching, Robot

programming languages, Structure of robot language, VAL programming.

UNIT V: APPLICATIONS OF INDUSTRIAL ROBOT	**06 Hrs.**

anufacturing applications of robot: Material handling, Machine loading / unloading, Spray painting, Welding, Machining, Assembly, pick and place, Inspection. **Non-manufacturing robotic applications:** Hazardous environment, Medical, Mining, Space, Defence, Security, Domestic, Entertainment, Agriculture, Distribution and others; Future of robotics. **Case Study for Robotic Applications** including Robot Selection considerations for a typical industrial application.

TEXT BOOKS:

1. S.K. Saha, *Introduction to Robotics*, McGraw Hill Education.
2. R.K. Mittal & I.J. Nagrath, *Robotics and Control*, Tata McGraw Hill.

REFERENCE BOOKS:

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson Education.
2. Saeed B. Niku, *Introduction to Robotics: Analysis, Control, Applications*, Wiley.
3. Mikell P. Groover, *Industrial Robotics: Technology, Programming, and Applications*, McGraw Hill.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0302	Mechatronics				PCC
Contact Hours per Week			CA	FE	Credits
L	P	S			
02	02	01	50+50	50	03

Prerequisite: Basic Electronics

Course Objectives:

1. To introduce the fundamentals and interdisciplinary nature of Mechatronics.
2. To select and apply appropriate sensors and actuators for measurement and control applications.
3. To explain and analyze signal conditioning, data acquisition, and interfacing for mechatronic applications.
4. To understand fundamentals of embedded control hardware, software concepts, and basic control techniques.
5. To apply systematic design principles to develop integrated Mechatronic systems

Course Outcomes:

On successful completion of the modules students will be able to:

CO1: Explain the fundamentals of mechatronics, and microprocessor-based control systems.

CO2: Interface appropriate sensors and actuators for mechatronic applications.

CO3: Develop PLC programs using ladder logic for industrial automation applications.
CO4: Design integrated mechatronic systems, and system modeling concepts.

UNIT I: Introduction to Mechatronics	06 Hrs.

Introduction: Mechatronics key elements, Design process and issues, Mechatronics in manufacturing, measurement system, microprocessor-based controllers, Products, and design. Comparison between Traditional and Mechatronics approach.

UNIT II: Sensors and Actuators in Mechatronic Systems	07 Hrs.

Sensors: Classification, selection criteria, characteristics, Signal conditioning, Working principles of displacement, position, proximity, force, pressure, temperature, speed, optical sensors and Limit Switches. Actuators: Types, selection criteria, characteristics, and applications of electrical actuators, pneumatic actuators, and actuator driver circuits.

UNIT III: Programmable Logic Controllers (PLC)	07 Hrs.

Introduction to embedded systems, PLC architecture and components, PLC programming concepts, I/o Processing, Sequencing, Logical operations, Timers and counters, shift registers, PLC-based system control, PLC applications in industrial automation and robotics.

UNIT IV: System Modelling and Mechatronic System Design	07Hrs.

Introduction to system modeling and simulation, Mechatronic system design methodology, Integration of sensors, actuators, controllers, and control logic, Case studies: Washing machine, ABS, pick-and-place robots

TEXT BOOKS:

- Bolton, W. Mechatronics, Pearson Education.
- Alciatore, D.G., and Histand, M.B. Introduction to Mechatronics and Measurement Systems, McGraw Hill.
- Shetty, D., and Kolk, R., A., Mechatronics System Design

REFERENCE BOOKS:

- N.P. Mahalik, Mechatronics: Principles, Concepts and Applications, Tata McGraw-Hill.
- F.D. Petruzella, Programmable Logic Controllers, McGraw-Hill.
- Ghosh & Raj, Fundamentals of Microprocessors and Microcontrollers, S. Chand.

List of Experiments:

1. Angular Displacement Measurement using Variable Capacitive Transducer
2. Speed Measurement using Inductive and Optical Transducer
3. To interface ADC 0809 with a clock generator and observe digital outputs using LED indicators
4. Study and Characterization of 8-bit Weighted Resistor Digital-to-Analog Converter using DAC0808
5. Introduction to PLC Hardware and Programming Environment
6. PLC architecture, ladder logic programming
7. PLC Programming for Digital Input–Output Control - Implementation of basic logic operations (AND, OR, NOT, NOR, NAND, XOR)
8. Control Using Counters: - Event counting and sequencing applications
9. Sequential Control using timers- ON-delay and OFF-delay timers
10. PLC Programming for Sequencing operations using shift registers
11. IoT-Based Monitoring and Control of a Mechatronic System

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><td>Course Code</td><td colspan="3">Course Title</td><td colspan="2">Category</td></tr>
<tr><td>26ES03TP0303</td><td colspan="3">Microcontroller and Interfacing</td><td colspan="2">PCC</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td>CA</td><td>ES</td><td>Credits</td></tr>
<tr><td>L</td><td>P</td><td>S</td><td>50</td><td>50</td><td>03</td></tr>
<tr><td>03</td><td>00</td><td>02</td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Prerequisite: Basic knowledge of digital electronics, logic gates, and number systems; fundamentals of electrical circuits; introductory programming concepts in C language; and basic understanding of signals and systems.</td></tr>
<tr><td colspan="6">Course Objectives: To provide fundamental knowledge of microprocessors and microcontrollers including 8051 microcontroller, 8086 microprocessor, and ARM Cortex-M series; to develop programming and interfacing skills using GPIO and communication protocols (wired and wireless); and to enable the design of real-time embedded systems for robotics and AI applications.</td></tr>
<tr><td colspan="6">Course Outcomes: On successful completion of the module students will be able to:
CO1: Explain the architecture and operation of microprocessors and microcontrollers, including 8086 microprocessor and 8051 microcontroller.
CO2: Develop and implement programs for modern embedded systems using ARM Cortex-M series with proper use of timers, interrupts, and peripherals.
CO3: Design and implement GPIO interfacing and communication interfaces using UART, SPI, I2C, and wireless protocols such as Bluetooth and Wi-Fi.
CO4: Interface sensors and actuators and apply control techniques such as PID control for robotic systems.
CO5: Design and analyze embedded systems using RTOS concepts and integrate AI-based functionalities for robotics and automation applications.</td></tr>
<tr><td colspan="4">UNIT I: Fundamentals of Microprocessors and Microcontrollers (8086 & 8051)</td><td colspan="2">08 Hrs.</td></tr>
<tr><td colspan="6">Introduction to embedded systems and their role in robotics and automation; comparison of microprocessors and microcontrollers; architecture of 8086 microprocessor—register organization, addressing modes, instruction set overview; architecture of 8051 microcontroller—memory organization, I/O ports, timers, interrupts; comparison and suitability for control-oriented applications.</td></tr>
<tr><td colspan="4">UNIT II: ARM Cortex Architecture and Programming</td><td colspan="2">08 Hrs.</td></tr>
</table>

Limitations of traditional controllers and need for 32-bit systems; architecture of ARM Cortex-M series core registers, Embedded C programming; register-level configuration; timers, interrupts, and PWM generation.

UNIT III: GPIO Interfacing and Communication Protocols	**08 Hrs.**

GPIO interfacing concepts—pin configuration, input/output modes, pull-up/pull-down resistors; interfacing of LEDs, switches, and digital devices; serial communication fundamentals; communication protocol interfacing (data formats, timing, configuration); interfacing sensors and peripherals using these protocols

UNIT IV: Wireless Communication and Sensor–Actuator Interfacing	**07 Hrs.**

Wireless communication fundamentals; interfacing of wireless protocols (Bluetooth, Wi-Fi, and Zigbee in embedded systems; integration with microcontrollers using UART/SPI); sensor interfacing (ultrasonic, IR, temperature, IMU); actuator interfacing (DC motors, servo, stepper motors); motor drivers; PWM-based control.

UNIT V: Real-Time Embedded Systems and AI-Based Robotics Applications	**07 Hrs.**

Introduction to real-time systems; task scheduling and synchronization; RTOS fundamentals using FreeRTOS; embedded system design methodology; IoT-based robotic systems; edge AI concepts; deployment using TensorFlow Lite; applications such as autonomous robots, smart automation, and remote-controlled robotic systems

TEXT BOOKS:

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, and Rolin McKinlay, *"The 8051 Microcontroller and Embedded Systems"*, Pearson Education.
2. Douglas V. Hall, *"Microprocessors and Interfacing: Programming and Hardware"* (for 8086 microprocessor), McGraw-Hill.
3. Joseph Yiu, *"The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors"* (for ARM Cortex-M series), Elsevier.

REFERENCE BOOKS:

1. Kenneth J. Ayala, *"The 8051 Microcontroller"*, Cengage Learning.
2. A.K. Ray and K.M. Bhurchandi, *"Advanced Microprocessors and Peripherals"*, McGraw-Hill.
3. Raj Kamal, *"Embedded Systems: Architecture, Programming and Design"*, McGraw-Hill.
4. Qing Li and Caroline Yao, *"Real-Time Concepts for Embedded Systems"* (for FreeRTOS concepts), CRC Press.

Experiment List

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Exp No	Experiment	CO Mapped
1	Write and execute an Assembly language program for basic data transfer and arithmetic operations in 8051 microcontroller	CO1, CO2
2	Write an Assembly language program to implement decision-making and array processing (largest/smallest number)	CO2
3	Write a program to interface a 4×4 matrix keypad with microcontroller and display the pressed key on an LED/LCD**.**	CO3, CO4
4	Write a program to interface an ADC with microcontroller to read analog input (e.g., temperature sensor or potentiometer) and display the digital output on LED/LCD**.**	CO2, CO5
5	Interface a 16×2 LCD with microcontroller and display dynamic messages	CO3
6	Interface and control a DC/Stepper motor for direction and speed control	CO4
7	Implement a traffic light control system using LEDs with timing logic	CO2, CO5
8	Implement UART communication between microcontroller and PC/controllers	CO3
9	Interface wireless module (Bluetooth/ZigBee/Wi-Fi) for sensor data transmission	CO3, CO5
10	Develop an ARM-based application using ARM Cortex-M series for sensor-based decision making	CO2, CO4, CO5

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0304	**Programming with Python**				PCC
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	P	**S**			
02	02	00	50 + 50	00	03

Prerequisite:

Course Objectives:
1. To provide students with a solid foundation in the Python programming language which makes them to understand and apply fundamental programming concepts
2. To develop students' ability to implement control flow constructs, modular programming through the use of functions

Course Outcomes: On successful completion of the module students will be able to:

CO1. Apply Python fundamentals, control structures, and basic programming constructs to develop logical solutions for computational problems.

CO2. Design and implement modular programs using functions and appropriate built-in data structures for efficient data manipulation.

CO3. Utilize file handling, exception management, and Python libraries to create robust and data-driven applications.

CO4. Integrate Python programming concepts to plan, develop, test, and document mini projects for real-world problem-solving.

UNIT I: Python Fundamentals and Control Structures	**08 Hrs.**
Python installation, IDEs (IDLE, VS Code), Python syntax, keywords, identifiers, variables, data types, type casting, input/output functions, arithmetic operators, logical operators, conditional statements (if, elif, else), loops (for, while), loop control statements (break, continue, pass)	
UNIT II: Functions, Modular Programming, and Data Structures	**9 Hrs.**
Function definition, calling functions, parameters, return values, variable scope (local, global), user-defined functions, string operations and methods, list creation and manipulation, tuple operations, dictionary operations, set operations, Concept of OOPs using Python	
UNIT III: File Handling, Exception Management, and Libraries	**9 Hrs.**
File operations (read, write, append), working with CSV files, structured data handling, exception handling (try, except, finally, raise), math library, random library, datetime library, introduction to numpy, introduction to pandas	

UNIT IV: Data Handling, Visualization, and Applications	**8 Hrs.**

Data processing tasks, data cleaning using Pandas, data analysis using NumPy and Pandas, data visualization using Matplotlib (plots, bar charts, histograms, customization), integration of Python concepts for problem-solving, project planning, coding and debugging, testing and documentation, mini project development and presentation.

Textbooks

1. Dr. Charles Severance, *Python for Everybody: Exploring Data in Python 3*, CreateSpace Independent Publishing, 2016.
2. Allen B. Downey, *Think Python: How to Think Like a Computer Scientist*, 2nd Edition, O'Reilly Media, 2016.
3. Mark Lutz, *Learning Python*, 5th Edition, O'Reilly Media, 2013.

Reference Books

1. Eric Matthes, *Python Crash Course: A Hands-On, Project-Based Introduction to Programming*, 2nd Edition, No Starch Press, 2019.
2. Paul Barry, *Head First Programming: A Learner's Guide to Programming Using Python*, O'Reilly Media, 2010.
3. Luciano Ramalho, *Fluent Python: Clear, Concise, and Effective Programming*, 2nd Edition, O'Reilly Media, 2022.
4. Wes McKinney, *Python for Data Analysis*, 3rd Edition, O'Reilly Media, 2022.

List of Experiments

UNIT I: PYTHON FUNDAMENTALS AND CONTROL STRUCTURES

1. Write a Python program to perform basic arithmetic operations (addition, subtraction, multiplication, division) using user input.
2. Develop a program to demonstrate the use of different data types and type casting.
3. Write a program to check whether a number is even or odd using conditional statements.

UNIT II: FUNCTIONS, MODULAR PROGRAMMING, AND DATA STRUCTURES

1. Write a program to define and call a user-defined function to calculate the sum of two numbers.
2. Develop a program demonstrating the use of function arguments and return values.
3. Write a program to demonstrate local and global variables.

UNIT III: FILE HANDLING, EXCEPTION MANAGEMENT, AND CORE LIBRARIES

1. Write a program to create, write, and read a text file.
2. Develop a program to handle exceptions using try, except, and finally blocks.
3. Write a program to demonstrate the use of the math, random, and datetime libraries.
4. Develop a program to read and write CSV files.

UNIT IV: DATA HANDLING, VISUALIZATION, AND APPLICATIONS

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

1. Write a program to clean a dataset using Pandas (handling missing values, duplicates).
2. Develop a program to filter and analyze data using Pandas.
3. Write a program to visualize data using Matplotlib (line plot, bar chart).
4. Develop a program to plot a histogram and pie chart using Matplotlib.
5. Write a program integrating NumPy and Pandas for data analysis.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03PR0405	Design Thinking				AEC
Contact Hours per Week			CA	ESE	Credits
L	P	S			
00	02	02	50	-	01

Prerequisite: Basic Engineering Design, Innovation Thinking

Course Outcomes: On successful completion of the module students will be able to:
CO1: Practice thinking as a tool for solving problems and generating ideas
CO2: Apply logical thinking in professional and quasi situations
CO3: Transduce the ideas into practically feasible inventions.
CO4: Incorporate design innovation in the product/processes.
CO5: Understand the importance of intellectual property

Expt. 1: Problem Identification and Need Analysis
Identification of real-world problems in Robotics & AI domain and formulation of problem statement.

Expt. 2: User Research and Survey Analysis
Design and conduct surveys/interviews to understand user needs and analyze collected data.

Expt. 3: Idea Generation Techniques
Application of brainstorming and SCAMPER techniques to generate multiple solution ideas.

Expt. 4: Concept Screening using Weighted Scoring Matrix
Evaluation and ranking of ideas based on defined criteria.

Expt. 5: Concept Selection using Pugh Matrix
Comparison of alternative concepts with a reference using + / – / 0 method.

Expt. 6: Technology Readiness Level (TRL) Assessment
Determination of maturity level of selected concept and analysis of associated risks.

Expt. 7: Concept Design and Product Planning
Development of design concepts using sketches and/or CAD models.

Expt. 8: Prototype Development (Minimum Viable Product)
Development of basic working prototype using suitable tools, hardware, and software.

Expt. 9: Testing, Validation and Iteration
Performance testing of prototype and implementation of design improvements.

Expt. 10: Business Model Canvas (BMC) Development
Preparation of BMC including customer segments, value proposition, and revenue streams.

Expt. 11: Cost Estimation and Market Analysis
Preparation of basic Bill of Materials (BOM), cost estimation, and identification of target market.

Expt. 12: Pitch Deck Preparation and Presentation
Development and presentation of pitch deck covering problem, solution, product, and business model.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS01TP0301	**Environmental Science**				VEC
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
01	02	00	50+50	-	**02**

Prerequisite:

Course Objectives:

1. To create awareness of environmental pollution, natural resources, and sustainability among engineering students.
2. To impart knowledge on ecological systems, biodiversity, and their conservation strategies.
3. To understand the causes and impacts of environmental degradation and climate change.
4. To familiarize students with various environmental policies, legal frameworks, and green technologies.

Course Outcomes: On successful completion of the module students will be able to:
CO1: Understand the importance of the environment, natural resources, and associated problems.
CO2: Explain the structure and function of ecosystems and the need for biodiversity conservation.
CO3: Analyze the causes of pollution and global environmental issues and evaluate control measures.
CO4: Apply knowledge of sustainable development and environmental protection laws in practical contexts.

UNIT I: Introduction to Environmental Studies and Natural Resources	**09 Hrs.**

Definition, scope and importance of environmental studies, Need for public awareness, Renewable and non-renewable resources, Forest resources: uses, overexploitation, deforestation and its impacts, Water resources: use and overutilization, water conflicts, floods, droughts, Mineral resources: exploitation and environmental effects, Energy resources: growing energy needs, solar, wind, geothermal and nuclear energy, Land resources: land degradation, soil erosion, desertification, Role of an individual in conservation of natural resources

UNIT II: Ecosystems and Biodiversity	**09 Hrs.**

Concept and structure of ecosystem, Components of ecosystem: producers, consumers, decomposers, Functions of ecosystem: energy flow, food chains, food webs, and ecological pyramids, Types of ecosystems: forest, grassland, desert, aquatic (freshwater and marine), Biodiversity: definition, levels (genetic, species, ecosystem), Biodiversity hotspots in India, Threats to biodiversity: habitat loss, poaching, man-wildlife conflicts, Endangered and endemic

species of India, Conservation of biodiversity: in-situ and ex-situ methods

UNIT III: Environmental Pollution and Global Issues	**9 Hrs.**

Types of pollution: air, water, soil, noise, causes, effects and control measures, Solid waste management: causes, effects and control measures of urban and industrial wastes, Wastewater treatment methods and recycling, Global warming and climate change: causes and impacts, Acid rain, ozone layer depletion, nuclear hazards, Disaster management: floods, earthquakes, cyclones, landslides, Role of technology and individuals in pollution control

UNIT IV: Social Issues, Environmental Laws and Sustainable Development	**9 Hrs.**

Architecture of microcontrollers (e.g., 8051, Arduino), Programming fundamentals, I/O interfacing: sensors, motors, display, Timers, interrupts, PWM, Communication protocols: UART, SPI, I2C.

UNIT V: Programmable Logic Controllers (PLC) and System Integration	**9 Hrs.**

Concept of sustainable development and green practices, Urban problems related to energy and population growth, Environmental ethics: issues and possible solutions, Environmental legislation in India: Water Act (1974), Air Act (1981), Environmental Protection Act (1986), Forest Conservation Act (1980), Role of Central and State Pollution Control Boards, Environmental impact assessment (EIA), Environmental management systems (ISO 14001), Green buildings and carbon footprint, Case studies on successful environmental movements (Chipko, Narmada Bachao Andolan)

TEXT BOOKS:1.

Erach Bharucha – Textbook of Environmental Studies for Undergraduate Courses, University Grants Commission, Orient BlackSwan Pvt. Ltd..

REFERENCE BOOKS:

1. R. Rajagopalan – Environmental Studies: From Crisis to Cure, Oxford University Press
2. Anubha Kaushik and C. P. Kaushik – Environmental Studies, New Age International Publishers
3. P. D. Sharma – Ecology and Environment, Rastogi Publications
4. Benny Joseph – Environmental Studies, Tata McGraw-Hill Education
5. G. Tyler Miller and Scott Spoolman – Environmental Science, Cengage Learning

Laboratory Experiments (Environmental Science Lab)

1. Determination of pH and conductivity of water samples
2. Estimation of Total Dissolved Solids (TDS) in drinking water
3. Measurement of air quality parameters (SO_2, NOx, PM2.5/PM10 using secondary data)
4. Analysis of soil texture, pH, and moisture content
5. Demonstration of water filtration and purification techniques
6. Study of biodiversity in a nearby area (quadrant method or campus flora survey)
7. Measurement of noise levels in different areas (e.g., residential vs traffic zones)

8. Visit to a water treatment plant or solid waste management facility
9. Simulation of climate change impact using a digital tool or case-based analysis
10. Preparation of a report on environmental problems in the local area and possible mitigation strategies.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

Semester-IV

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

SEMESTER IV					
Course Code	**Course Title**				**Category**
26ES03TP0401	**Kinematics and Dynamics of Robot**				PCC
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**S**			
03	02		50+50	50	**04**

Prerequisites:

Students should have:

- Basic knowledge of **mathematics** (linear algebra, trigonometry, and calculus).
- Understanding of **engineering mechanics, rigid body motion, coordinate systems, and machine kinematics**.

Course Objectives:

After completing this course, students will be able to:

1. Understand and apply coordinate transformations and frame mapping for representing robotic systems.
2. Develop forward kinematic models of robotic manipulators using D-H parameters.
3. Formulate and solve inverse kinematics problems for different robotic configurations.
4. Analyze velocity relationships, Jacobian matrix, and singularities in robotic manipulators.
5. Model and analyze robot dynamics and trajectory planning for controlled motion.

Course Outcomes (CO)

After successful completion of the course, students will be able to:

CO1: Apply coordinate frame transformations and homogeneous matrices to represent position and orientation of robotic systems.
CO2: Develop and analyze forward kinematics models of manipulators using Denavit–Hartenberg (D-H) convention.
CO3: Solve inverse kinematics problems and evaluate multiple solutions, singularities, and workspace constraints.
CO4: Analyze Jacobian matrices, velocity relationships, and manipulability of robotic systems.
CO5: Formulate dynamic models and trajectory plans for robotic manipulators using Lagrangian and Newton–Euler methods.

UNIT I: Coordinate Frames, Mapping & Transforms	**08 Hrs.**

Significance of Coordinate Frames, Mapping & Transforms in robotics. Description of object in space, Mapping between rotated frames, translated frame and combined rotation & translation. Homogeneous transformation, Difference between fixed & movable frame, Composite/multiple transformation, Fixed angle rotation and Euler angle rotation.

UNIT II: Forward Kinematics of Robot	**08 Hrs.**

Introduction manipulator kinematics, Mechanical structure and notation, Description of links and joints, kinematic modelling of the manipulator, Difference between direct and inverse kinematics, Denavit-Hartenberg (D-H) notation and algorithms, Kinematic relationship between adjacent link, Manipulator Transformation Matrix, Workspace analysis.

UNIT III: Inverse Kinematics of Robot	**08 Hrs.**

Problem formulation of inverse kinematics, Analytical and numerical methods, Closed-form solutions for simple manipulators (2R and 3R planer), Redundant manipulators, Multiple solutions and singular configurations, Workspace and reachability analysis

UNIT IV: Jacobian and Singularity Analysis	**8 Hrs.**

Linear and angular velocity of a rigid body, relationship between transformation matrix and angular velocity, Jacobian matrix and its significance, Jacobian inverse, Jacobian Singularity, Manipulability, Dexterity analysis of manipulators, Redundancy and its impact on kinematic performance.

UNIT V: Dynamic modelling & Trajectory planning	**8 Hrs.**

Lagrangian mechanics, Dynamic model of n-DOF manipulator, Lagrange-Euler and Newton-Euler formulation to dynamic solution. Inverse Dynamics, Terminology related to trajectory planning, trajectory planning to determine the joint velocity and acceleration.

TEXT BOOKS:

- Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
- Craig J. J., Introduction to Robotics: Mechanics and Control, 3rd Edition, Addison-Wesley, Reading, MA, 2005.
- Odrey, Mikell P. Groover& Nicholas G., Mitchel Weiss, Roger N. Nagel, and Ashish Dutta. "Industrial Robotics,
- Technology programming and Applications.", McGraw Hill Education; 2nd edition (July 2017).

REFERENCE BOOKS:

- P. A. Janaki Raman, Robotics and Image Processing An Introduction, Tata MCGraw Hill Publishing company Ltd., 1995.
- Shames I. H., Engineering Mechanics- Statics and Dynamics" $/e Prentice-Hall of India Pvt. Ltd., 2005.

Kinematics and Dynamics of Robot Lab

Course Objectives:

The objectives of this course are to:

1. **Develop proficiency** in using MATLAB, RoboAnalyser, and industrial robot programming tools for robotic system analysis.
2. **Understand and validate** the kinematic and dynamic behavior of robotic manipulators through modeling and simulation.
3. **Apply** trajectory planning and motion control techniques for robotic manipulators using

simulation software.

4. **Gain hands-on experience** in programming and operating a six-axis industrial robot for various robotic tasks.
5. **Perform industrial robotic applications**, including path planning and welding operations, while following standard safety and operational practices.

Course Outcomes:

After successful completion of this course, the students will be able to:

1. Apply MATLAB and RoboAnalyser tools to model and analyze robotic systems.
2. Develop and validate kinematic models of robotic manipulators using analytical and simulation techniques.
3. Analyze robot motion, trajectory planning, and dynamic behaviour using computational tools.
4. Demonstrate robot programming and motion control for industrial robotic applications.
5. Execute robotic path planning and welding operations using a six-axis industrial robot.

List of Experiments:

1. Introduction to MATLAB symbolic tool box
2. Familiarization with the structure and working of six axis YASKAWA arc welding robot.
3. Study and Implementation of Homogeneous Transformations in Robotics using RoboAnalyser
4. Forward kinematics (FK) of n-DOF robots using RoboAnalyser and validate the FK solution with MATLAB.
5. Forward Kinematic Modeling of a Six-Axis YASKAWA Arc Welding Robot via Physical Measurement of D-H Parameters.
6. Inverse kinematics (FK) of n-DOF robots using RoboAnalyser and validate the FK solution with MATLAB.
7. Trajectory Planning of n-DOF robots using RoboAnalyser.
8. Forward dynamics of n-DOF robots using RoboAnalyser.
9. Inverse dynamics of n-DOF robots using RoboAnalyser.
10. Robot programming of six axis YASKAWA arc welding robot.
11. Straight-Line Butt-Welding Path Planning using six axis YASKAWA arc welding robot.
12. Circular Welding on Pipe or Plate Path Planning using six axis YASKAWA arc welding robot.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0402	Control Systems Engineering Semester IV				PCC
Contact Hours per Week			CA	FE	Credits
L	P	S			
3	2	-	50 + 50	50	04

Prerequisite: Students should have basic knowledge of Engineering Mathematics, Differential Equations, Laplace Transform and basic Electrical Engineering. Familiarity with Mechanical Systems and Sensors will be beneficial.

Course Objectives:
After completing this course, students will be able to:

1. Understand fundamental concepts of control systems and their role
2. Analyse mathematical models of dynamic systems
3. Understand stability of control systems and analyse control techniques for engineering systems

Course Outcomes:

After successful completion of the course, students will be able to:
CO1: Understand the basic concepts of control systems, including open-loop control systems and closed-loop control systems and their working principles
CO2: Develop mathematical models of systems using transfer functions
CO3: Analyse time response and frequency response of control systems
CO4: Evaluate stability of control systems by plotting bode and polar plots
CO5: Understand and apply controllers such as PID for industrial applications

UNIT I: Introduction to Control Systems	**8 Hours**
Basic concepts of control systems, open-loop and closed-loop systems, examples from robotics, mathematical modeling of physical systems (mechanical and electrical), transfer function representation, block diagrams and signal flow graphs.	
UNIT II: Time Response Analysis	**7 Hours**
Standard test signals, time response of first and second order systems, transient and steady-state response, time domain specifications, error analysis and steady-state error constants.	
UNIT III: Stability Analysis	**7 Hours**
Concept of stability, Routh-Hurwitz stability criterion, root locus technique, construction of root locus, effects of poles and zeros on system behaviour.	
UNIT IV: Frequency Response Analysis	**7 Hours**

Frequency response concepts, Bode plots, Polar plots, gain margin and phase margin, stability analysis using frequency response methods.

UNIT V: Controllers and its Applications	**7 Hours**

Introduction to controllers, types of controllers, working of controllers, controller tuning methods, applications of controllers, introduction to modern controllers, case studies and examples.

TEXT BOOKS:

1. K. Ogata, *Modern Control Engineering*, Prentice Hall.
2. I. J. Nagrath & M. Gopal, *Control Systems Engineering*, New Age Publications.

REFERENCE BOOKS:

1. Benjamin C. Kuo, *Automatic Control Systems*, Wiley.
2. Norman S. Nise, *Control Systems Engineering*, Wiley.
3. Richard C. Dorf & Robert H. Bishop, *Modern Control Systems*, Pearson.

List of Practical

1. To study the basic concepts of control systems with suitable examples of open-loop and closed-loop systems.

2. To demonstrate the potentiometer as an error detector using block diagram representation.

3. To demonstrate the synchro system as an error detector based on transmitter-receiver configuration.

4. To demonstrate the DC position control system using servo potentiometer and analyse the effect of controller gain on system performance.

5. To obtain and plot the torque-speed characteristics of an AC servo motor.

6. To demonstrate a temperature control system for oven using PID controller and analyse the time response characteristics of a second-order system.

7. To demonstrate and plot the time response of a second-order system using an RLC circuit.

8. To analyze the root locus of given open-loop transfer functions and check system stability using MATLAB (for two cases).

9. To analyze Bode plot of a given open-loop transfer functions and evaluate gain margin, phase margin and system stability using MATLAB.

10. To analyze Polar plot of given transfer function and evaluate gain margin and phase margin using MATLAB (for single case)

Ramdeobaba University, Nagpur

Department of Mechanical Engineering, School of Engineering Sciences

Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence

Session: 2026-27

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0403	**Artificial Intelligence**				PCC
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**S**			
03	02	00	50+50	50	**04**

Course Objectives:

After completing this course, students will be able to:

1. Basic problem-solving techniques, intelligent agents, and AI applications in real-world scenarios.
2. Representation of problems using state space and solving them using classical and heuristic search techniques.
3. Adversarial search, constraint satisfaction, and introductory learning approaches in AI.
4. Knowledge representation, uncertainty handling, and introductory concepts of modern AI such as Transformers & LLMs.

Course Outcomes (CO)

After successful completion of the course, students will be able to:

CO1: Explain fundamental concepts of artificial intelligence and intelligent agents
CO2: Apply search algorithms to solve simple AI problems
CO3: Analyze adversarial and constraint satisfaction problems
CO4: Evaluate knowledge representation and uncertainty techniques
CO5: Explain basic concepts of modern AI including neural networks, Transformers, LLMs, and RAG

UNIT I: Introduction to Artificial Intelligence and Agents	**08 Hrs.**
Introduction to AI, history and applications, task domains, Basics of problem solving, problem characteristics, problem representation (toy and real-world problems); Intelligent agents, rational agents, task environment, performance measures, simple real-world examples of AI systems	
UNIT II: Uninformed Search Techniques	**08 Hrs.**
State space representation, Breadth First Search, Depth First Search, Uniform Cost Search, Depth Limited Search, Iterative Deepening DFS, Bidirectional Search, simple problem-solving examples	
UNIT III: Informed Search and Learning Basics	**08 Hrs.**
Heuristic based search, Greedy Best First Search, A* Search; Local search algorithms: Hill-climbing, Genetic Algorithms (conceptual); Introduction to learning in AI, basic idea of machine learning	
UNIT IV: Adversarial Search and Constraint Satisfaction	**8 Hrs.**
Two-player games, Min-Max algorithm, Alpha-Beta pruning (conceptual); Constraint Satisfaction Problems, backtracking search, constraint propagation, real-world examples (puzzles, scheduling)	
UNIT V: Knowledge Representation and Introduction to Modern AI	**8 Hrs.**

Propositional logic, First Order Logic (basic syntax and semantics), inference mechanisms (forward and backward chaining); Introduction to probability and Bayes' theorem, Naïve Bayes (concept only);

Basics of neural networks, Introduction to Transformer (attention concept), overview of Large Language Models (LLMs), basic prompt engineering.

TEXT BOOKS:

1. Artificial Intelligence: A Modern Approach — Stuart Russell, Peter Norvig, Pearson, 4th Edition
2. Artificial Intelligence — Elaine Rich, Kevin Knight, McGraw-Hill Education

REFERENCE BOOKS:

1. Machine Learning — Tom M. Mitchell, McGraw-Hill Education
2. Pattern Recognition and Machine Learning — Christopher M. Bishop, Springer
3. Deep Learning — Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03PR0404	**Mini Project-1**				CFP/MP
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**T**	**P**			
00	00	02	50	-	01

Prerequisite: Introduction to Python,

Course Objectives:
1. To enable students to identify, analyze, and define a real-world engineering problem and develop an appropriate problem statement through literature review and preliminary investigation.
2. To develop skills in project planning, research methodology, and initial design or model development using appropriate tools and techniques.

Course Outcomes: On successful completion of the module students will be able to:
CO1 Identify and define a real-world problem related to Robotics and Artificial Intelligence by reviewing relevant literature and understanding system requirements.

CO2 Analyze and design an appropriate methodology or system architecture using fundamental concepts of AI, ML, robotics, sensors, and automation.

CO3 Implement a basic hardware/software solution using suitable tools, programming languages, or simulation platforms to address the identified problem.

CO4 Evaluate and interpret results obtained from the developed system and analyze performance with respect to objectives and constraints.

CO5 Demonstrate effective teamwork and technical communication through seminars, presentations, documentation, and viva-voce.

SYLLABUS	**25 Hrs.**

Introduction to project-based learning, identification of problem domains, literature survey and review of research papers, formulation of problem statement and objectives, feasibility analysis, selection of methodology and tools, basic design or model development, data collection and preliminary analysis, use of computational or experimental techniques, project planning and scheduling, documentation practices, report writing, and presentation of progress work.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03AECPR0408	Algorithmic Problem Solving-I				AEC
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
00	02	00	50	00	01

Prerequisite: Basics of Python and Data Structure

Course will be delivered by Industry Vendor.

Course Objectives:

- To develop fundamental problem-solving skills using basic data structures and algorithms.
- To enable students to solve coding problems using online competitive platforms.

Course Outcome :

1. Understand problem statements and implement basic algorithms.
2. Apply arrays and string manipulation techniques.
3. Solve problems using recursion and basic backtracking.
4. Implement searching and sorting techniques.
5. Use online assessment effectively for coding practice.

Module 1: Fundamentals & Problem Solving 04x2 Hrs

1. Algorithm basics, pseudocode, flowcharts
2. Time & space complexity (intro level)
3. Input/output handling in coding platforms

Module 2: Arrays, Strings & Recursion 04x2 Hrs

1. 1D/2D arrays
2. String operations
3. Recursion basics (factorial, Fibonacci, simple problems)

Module 3: Searching, Sorting & Basic Data Structures 04x2 Hrs

- Linear & binary search
- Basic sorting (bubble, selection, insertion)
- Introduction to stacks & queues

LIST OF EXPERIMENTS

1. Solve 5 problems on basic input/output and logic building
2. Implement array operations (search, sum, reverse)
3. String manipulation problems (palindrome, substring, frequency count)
4. Recursive problems (factorial, Fibonacci, sum of digits)
5. Searching & sorting implementation and problem-solving
6. Solve at least 10 problems on HackerRank (Easy level)
7. Mini contest (timed coding test)

Recommended Books

1. "Data Structures Using C" – Reema Thareja
2. "Introduction to Algorithms" – Cormen (Basic reference)
3. "Programming in C/C++/Java" – Standard texts

Web Resources

- HackerRank
- HackerEarth
- LeetCode
- CodeChef, GeeksforGeeks

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	**Course Title**				**Category**
26HS04PR0401	Self-Défense & Indian Martial Art				Audit
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	P	**S**			
00	02	00	50		00

Course Description
Self-Défense & Indian Martial Arts is a life skills training program aimed at enhancing personal safety, especially for young women. It combines traditional Indian martial arts with modern self-defense techniques, focusing on physical fitness, mental resilience, and situational awareness.

Course Objective

This course aims to equip students—particularly female students—with the foundational skills and knowledge of essential self-defense techniques and Bhartiya Yudhkala (Indian Martial Arts). By the end of the program, students will possess increased awareness, confidence, and practical ability to protect themselves in potentially dangerous situations.

Course Outcomes
CO1: Demonstrate situational awareness and psychological preparedness by identifying potential threats and responding appropriately in guided scenarios.
CO2: Accurately target vulnerable body points during controlled practice and roleplay situations.
CO3: Execute and coordinate ground defense and escape techniques effectively in simulated confrontations.
CO4: Apply improvised weapon techniques and basic stick defense skills while following safety protocols and legal considerations.

Module 1 – Introduction
- Overview of self-defense, importance, mindset training, and history of Indian martial arts.
- Basics of situational awareness and psychological preparedness.

Module 2 – Targeting Weak Points
- Anatomical knowledge for self-defense: eyes, nose, throat, groin, knees.
- Practice and roleplay scenarios.

Module 3 – Ground Défense
- Techniques to defend and escape when on the ground.
- Partner practice and resistance drills.

Module 4 – 20 Escape Techniques Through Indian Culture
- Practical escape methods inspired by traditional Indian martial forms.
- Application in staged confrontation settings.

Module 5 – Weapon of Opportunity
- Training with improvised weapons: pen, keys, dupatta, bags, etc.

• Timing, precision, and legal considerations.
Module 6 – Stick Rotation • Basics of stick (lathi/danda) handling and defence. • Practice with focus on flow, blocking, and disarming.
Text books & Reference books

B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

Semester-V

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th colspan="6">SEMESTER V</th></tr>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>26ES03TP0501</td><td colspan="4">Machine Learning</td><td>PCC</td></tr>
<tr><th colspan="3" rowspan="2">Contact Hours per Week</th><th rowspan="2">CA</th><th rowspan="2">ESE</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>P</th><th>S</th></tr>
<tr><td>03</td><td>02</td><td>01</td><td>50+50</td><td>50</td><td>04</td></tr>
<tr><td colspan="6">Prerequisite: Introduction to Python.</td></tr>
<tr><td colspan="6">Course Objectives:
1. To equip students with machine learning concepts and their applications in the robotics and AI field.
2. To learn data preprocessing techniques, supervised and unsupervised learning models, and deep learning approaches for mechanical systems.</td></tr>
<tr><td colspan="6">Course Outcomes: On successful completion of the module students will be able to:

CO1. Explain the fundamental concepts, types, and workflow of machine learning, and perform data preprocessing using Python tools.

CO2. Apply supervised learning algorithms for regression and classification tasks, and evaluate their performance using appropriate metrics.

CO3. Implement unsupervised learning and dimensionality reduction techniques for exploratory data analysis and pattern discovery.

CO4. Utilize ensemble methods, model selection strategies, and optimization techniques to improve predictive model performance.</td></tr>
</table>

CO5. Develop and apply basic neural network models and evaluate real-world ML applications with consideration for ethical implications.

UNIT I: Foundations of Machine Learning and Data Preprocessing	**09 Hrs.**

Introduction to machine learning & sklearn libraries, types of machine learning (supervised, unsupervised, reinforcement), machine learning workflow, data collection and cleaning, handling missing values, outlier detection, encoding categorical variables, feature scaling (normalization, standardization), train-test split, K-fold cross-validation

UNIT II: Supervised Learning – Regression and Classification Techniques	**09 Hrs.**

Simple linear regression, multiple linear regression, polynomial regression, assumptions of regression, overfitting and underfitting, ridge regression (L2), lasso regression (L1), elastic net, evaluation metrics (MAE, MSE, RMSE, R^2 score), logistic regression, k-nearest neighbors (k-NN), decision trees (Gini index, entropy), random forest classifier, support vector machines (SVM) with kernel trick, confusion matrix, accuracy, precision, recall, F1-score, ROC curve, AUC, stratified sampling, model visualization using matplotlib and seaborn, implementation in scikit-learn

UNIT III: Unsupervised Learning and Dimensionality Reduction	**9 Hrs.**

k-means clustering, elbow method, silhouette score,hierarchical clustering, dendrograms, DBSCAN algorithm, principal component analysis (PCA), t-SNE for data visualization, comparison of clustering techniques, customer segmentation, anomaly detection

UNIT IV: Ensemble Learning, Model Selection, and Optimization	**9 Hrs.**

Ensemble learning concepts, bagging, boosting, stacking, random forest (bagging), AdaBoost, gradient boosting (GBM, XGBoost), bias-variance trade-off, model selection, hyperparameter tuning with grid search and random search, K-fold and stratified cross-validation, feature importance, building pipelines in scikit-learn

UNIT V: Neural Networks and Applications of Machine Learning	**9 Hrs.**

Introduction to neural networks, perceptron model, activation functions (sigmoid, tanh, ReLU), multilayer perceptron (MLP), forward and backward propagation (conceptual), gradient descent optimization, introduction to TensorFlow and Keras.

TEXT BOOKS:

1. Pattern Recognition and Machine Learning by Christopher M. Bishop – A comprehensive guide to statistical pattern recognition and machine learning with a strong mathematical foundation.
2. Machine Learning by Tom M. Mitchell – A classic introductory book covering key ML

algorithms with intuitive explanations.

REFERENCE BOOKS:

1. An Introduction to Statistical Learning by Gareth James et al. – Beginner-friendly ML book with R-based applications and statistical insights.
2. The Elements of Statistical Learning by Hastie, Tibshirani, Friedman – Advanced text on statistical models and learning theory for experienced readers.

List of Experiment

1. Implement data preprocessing techniques: handling missing values, encoding categorical variables, feature scaling.
2. Perform exploratory data analysis (EDA) using statistical summaries and visualization.
3. Implement Simple Linear Regression using Scikit-learn.
4. Perform Multiple Linear Regression and evaluate model performance (R^2, MSE).
5. Implement Logistic Regression for binary classification.
6. Perform classification using K-Nearest Neighbors (KNN) algorithm.
7. Implement Decision Tree classifier and visualize the tree.
8. Implement K-Means clustering and visualize clusters.
9. Perform Hierarchical clustering and plot dendrogram.
10. Apply Principal Component Analysis (PCA) for dimensionality reduction.
11. Compare clustering results before and after dimensionality reduction.
12. Analyze real datasets using clustering techniques.
13. Implement Random Forest algorithm for classification and regression and Apply Cross-Validation techniques for model evaluation.
14. Perform Bagging and Boosting techniques (AdaBoost).
15. Perform hyperparameter tuning using Grid Search.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0502	Industrial Hydraulics and Pneumatics				PCC
Contact Hours per Week			CA	FE	Credits
L	P	S			
3	2	1	50+50	50	04

Prerequisite: Basics of Fluid Power Systems

Course Objectives:

1. To understand the fundamental principles of industrial hydraulics and pneumatics, including fluid properties, system components, and working mechanisms.

2. To develop the ability to analyze, design, and troubleshoot hydraulic and pneumatic systems used in industrial applications.

Course Outcomes:

CO1: Explain the working principles of hydraulic and pneumatic systems and their components.

CO2: Identify and select suitable pumps, actuators, valves, and accessories for industrial applications.

CO3: Analyze hydraulic and pneumatic circuits used in machine tools and automation systems.

CO4: Design basic industrial circuits for given applications such as press, drilling, and pick-and-place systems.

CO5: Diagnose and troubleshoot faults in fluid power systems and suggest appropriate maintenance practices.

UNIT I: Fundamentals of Fluid Power Systems	**8Hrs.**

Introduction to fluid power systems , Advantages, limitations, and industrial applications, Comparison of hydraulic and pneumatic systems,Types of fluids: hydraulic fluids and compressed air, Properties of fluids: viscosity, density, compressibility, lubrication, contamination, Selection criteria for hydraulic fluids ,Basic principles of hydraulics, Pascal's Law and its applications,Sources of hydraulic power: pumps and compressors (overview), Classification of hydraulic pumps

UNIT II: Hydraulic Pumps and Actuators	**8Hrs.**

Hydraulic Pumps: Types: Gear, Vane, Piston pumps,Construction, working principle, and performance characteristics,Advantages, disadvantages, and industrial applications

Hydraulic Actuators :Hydraulic cylinders: Types (single acting, double acting, telescopic, etc.) ,Construction and working,Mounting methods and applications ,Hydraulic motors: Types, construction, and working , Introduction to hydraulic cushioning

UNIT III: Hydraulic Control Components and Circuits	**8Hrs.**
Control Valves: Direction control valves (DCV): types and operation ,Flow control valves: throttle, pressure compensated ,Pressure control valves: relief, reducing, sequence, unloading,**Hydraulic Circuits:**Basic and industrial circuits,Regenerative circuit ,Pump unloading circuit ,Double-pump system,Pressure intensifier circuit ,Sequence and interlocking circuits ,Speed control circuits ,Fail-safe circuits,Hydraulic accumulators and their applications ,& Pipes: Types, Materials, pressure drop in hoses/pipes. Hydraulic piping connections.	
UNIT IV: Pneumatic Systems and Electro-Pneumatics	**8Hrs.**
Properties of compressed air,**Perfect Gas Laws** and their applications in pneumatics,Air generation and distribution: compressors and air receivers ,Air preparation units: Filter, Regulator, Lubricator (FRL),Pneumatic control valves: DCV, flow and pressure control valves ,Special valves: quick exhaust valve, shuttle valve ,Pneumatic actuators: cylinders and air motors,**Electro-pneumatic systems:**Solenoid valves ,Sensors and limit switches ,Basic electro-pneumatic circuits.	
UNIT V: Industrial Applications, Design and Troubleshooting	**8Hrs.**
Design of hydraulic circuits for industrial applications:Hydraulic press,Drilling machine,Surface grinding machine ,Forklift system **Design of pneumatic circuits**:Pick-and-place operations ,Tool handling in CNC machines,Installation and maintenance practices, Common faults in hydraulic and pneumatic systems ,Troubleshooting techniques and remedies , Safety considerations in industrial fluid power systems	
TEXT BOOKS: 1. Sahashtrabudhe N.V., Introduction to Fluid Power, Nirali Prakashan Pune. 2. Pipenger J.J., Industrial Hydraulics, McGraw Hill Co. 3. Mujumdar S.R., Pneumatics circuits.	
REFERENCE BOOKS: 1. Pinches, Industrial Fluid Power, Prentice Hall. 2. Stewart H.L., Hydraulics & Pneumatics, Industrial Press. 3. Fluid Power Design Handbook, Yeaple.	
LIST OF PRACTICAL ASSIGNMENTS: Any 8 (for lab course) 1) Study of hydraulic fluids and seals used in fluid power systems. 2) Study of contamination of hydraulic fluids and its control.	

3) Study of symbols used in hydraulic and pneumatic systems.

4) Study of hydraulic pumps, accumulators and intensifiers.

5) Study of control valves used in hydraulic systems.

6) Study and demonstration of hydraulic circuits used in

(a) CNC Lathe (b) CNC Milling Machine (c) Universal Testing Machine

7) Study of air preparatory unit used in pneumatic systems.

8) Study of control valves used in pneumatic systems.

9) Study and demonstration of following pneumatic circuits on pneumatic circuit trainer:

[a] Control of single acting cylinder using 3/2 D.C. valves (Push button type, Hand lever type and Foot pedal type)

[b] Meter in circuit using double acting cylinder

[c] Meter out circuit using double acting cylinder

[d] Automatic sequencing of motion of 2 double acting cylinders using 5/2 pilot operated D.C. valves

[e] Automatic sequencing of motion of 2 double acting cylinders using Solenoid actuated D.C. valves.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>26ES03TP0503</td><td colspan="4">Industrial Internet of things (IIoT)</td><td>PCC</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">ESE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>P</td><td>S</td></tr>
<tr><td>2</td><td>2</td><td>2</td><td>50+50</td><td>50</td><td>3</td></tr>
<tr><td colspan="6">Prerequisite: Engineering Mathematics, Basics of Electrical Engineering, Python Programming,</td></tr>
<tr><td colspan="6">Course Objectives: The objective of the course is to prepare the students
1. To understand architecture and components of Industrial IoT systems.
2. To develop skills for data acquisition, analysis, and smart manufacturing applications.</td></tr>
<tr><td colspan="6">Course Outcomes: After completing this course, students will be able to:
CO1: Explain IIoT architecture, sensors, and communication protocols
CO2: Develop IoT-based data acquisition systems using hardware/software tools
CO3: Analyze industrial data using cloud platforms and basic analytics
CO4: Implement IIoT solutions with machine learning for predictive maintenance
CO5: Design smart manufacturing/monitoring systems for real-world applications</td></tr>
<tr><td colspan="6">Unit I: The Industrial Edge (Hardware & Sensing)
IIoT Fundamentals: Definitions, evolution from M2M, and the 4-layer architecture (Perception, Network, Middleware, Application).
The Physical Layer: Sensors: Theory and application of Temperature, Pressure, Vibration, Flow, Proximity, and LVDT, Actuators: Solenoids, Servo drives, VFDs, and Pneumatic systems. Signal conditioning (Amplifiers, Filters), ADC/DAC, and Data Acquisition Systems (DAQ).</td></tr>
<tr><td colspan="6">Unit II: Embedded Intelligence & Local Connectivity
Controller Platforms: Microprocessors vs. Microcontrollers; hands-on overview of Arduino, ESP32, and Raspberry Pi.
Edge Programming: GPIO programming with Python (Digital I/O, PWM) on Raspberry Pi.
Wired Bus Protocols: Principles and wiring for UART, SPI, and I2C.
Industrial Networking: Modbus (RTU/TCP): Architecture and frame structure, OPC-UA: The modern standard for industrial interoperability.</td></tr>
</table>

Unit III: IIoT Communication & Cloud Integration

Wireless Stack: Comparison of Wi-Fi, Zigbee, LoRaWAN, and NB-IoT (Range vs. Power vs. Reliability).

Messaging Protocols: MQTT: Deep dive into Broker, Pub/Sub model, and QoS levels, Web Protocols: HTTP/REST for IoT.

Cloud Ecosystems: Integration with AWS IoT Core, Microsoft Azure IoT Hub, and ThingSpeak, Middleware: Hands-on with HiveMQ or Mosquitto brokers.

Unit IV: Data Engineering & Industrial Analytics

Data Management: Time-series databases (InfluxDB), Data logging, and visualization with Grafana.

Preprocessing Pipeline: Using Python (Pandas, NumPy) for cleaning, normalization, and feature extraction.

Machine Learning for IIoT: Supervised(Regression and Classification) basics via scikit-learn.

Predictive Maintenance: Random Forest for Remaining Useful Life (RUL) prediction.

Unit V: Industry 4.0 Applications & Security

The Digital Twin: Concepts, architecture, and applications in manufacturing.

Smart Factory Operations: Condition monitoring and OEE (Overall Equipment Effectiveness) calculation, IIoT in Energy Management: Smart metering and demand response.

Capstone Case Study: End-to-end pipeline (Sensor - MQTT - Cloud - ML Model - Alert).

TEXT BOOKS:

1. Raj Kamal – Internet of Things

2. Programming the Internet of Things Andy King, O'Reilly Media 2021

3. Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow

4. Raspberry Pi and Python for IIoT Applications Warren Gay, Apress 2019

REFERENCE BOOKS:

1. Aurélien Géron, O'Reilly Media 3rd Ed., 2022

2. Industrial Internet of Things, Sabina Jeschke, Christian Brecher et al., Springer 2017

List of Experiments

1. Introduction to Raspberry Pi / ESP32: GPIO configuration, LED blink, button input using Python
2. Interfacing Temperature & Humidity Sensor (DHT22) with Raspberry Pi; data logging to CSV
3. Interfacing Vibration Sensor (ADXL345) via I2C; reading accelerometer data using Python
4. PWM-based DC motor speed control using Python and L298N motor driver (Actuator experiment)
5. Serial communication (UART/Modbus RTU) between Arduino and Raspberry Pi; data exchange
6. MQTT communication: publish sensor data from ESP32, subscribe and display on Raspberry Pi broker
7. Cloud data upload: send sensor readings to ThingSpeak / AWS IoT Core via Wi-Fi; real-time dashboard
8. Edge data processing: local anomaly detection on Raspberry Pi before cloud upload
9. Data pre-processing with Python (Pandas): cleaning noisy sensor dataset, normalization, feature extraction
10. Machine Learning Experiment – 1: Train a Random Forest regression model (scikit-learn) on industrial sensor data to predict Remaining Useful Life (RUL) of a simulated bearing
11. Machine Learning Experiment – 2: Anomaly detection using Isolation Forest on vibration/temperature dataset; visualize detected anomalies using Matplotlib
12. Mini-Project / Integration Experiment: End-to-end IIoT pipeline – sensor data acquisition → MQTT → cloud → ML anomaly alert → Grafana dashboard (group exercise)

Capstone projects linked experiments AI & IoT (One grop one project):

- Sensor Data Analytics using AI (Temperature & Humidity Prediction)
- Anomaly Detection in Sensor Data using Artificial Intelligence
- Smart Alert System for Fire / Equipment Overheating Detection using AI Rule-Based Classification
- Predictive Maintenance System using AI for Industry 4.0
- ML-Based Energy Consumption Prediction using Time-Series Forecasting

Additional Resources:

1. NPTEL 'Internet of Things' – Prof. Sudip Misra, IIT Kharagpur: https://nptel.ac.in/courses/106105173
2. NPTEL 'Introduction to Industry 4.0 and Industrial Internet of Things' – IIT Kharagpur: https://nptel.ac.in/courses/106105155
3. NPTEL 'Machine Learning' – Prof. Balaram Ravindran, IIT Madras: https://nptel.ac.in/courses/106106139
4. Platform Wokwi Online Arduino / ESP32 Simulator: https://wokwi.com
5. Platform ThingSpeak IoT Analytics Platform (free): https://thingspeak.com
6. Platform AWS IoT Core Free Tier: https://aws.amazon.com/iot-core
7. Platform HiveMQ Public MQTT Broker: https://www.hivemq.com/public-mqtt-broker
8. Coding Google Colab (free Python/Jupyter): https://colab.research.google.com
9. Coding Kaggle Datasets for IIoT ML: https://www.kaggle.com/datasets (search 'predictive maintenance', 'bearing fault')

Ramdeobaba University, Nagpur

Department of Mechanical Engineering, School of Engineering Sciences

Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence

Session: 2026-27

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03PR0505	**Mini Project II**				CEP/FP
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**S**			
00	02	00	50	00	01

Course Objectives:

1. To enable students to implement, test, and validate the proposed solution for the identified engineering problem using appropriate tools and techniques in a relevant industry.
2. To develop skills in analysis, interpretation of results, and effective presentation of the complete project work.

Course Outcomes: On successful completion of the module students will be able to:

CO1: Implement the proposed solution using appropriate engineering tools, techniques, or software in Robotics and AI Field.

CO2: Conduct experiments or simulations and collect relevant data for validation.

CO3: Analyze and interpret results to evaluate system performance and effectiveness.

CO4: Optimise and refine the developed system based on observations and findings.

CO5: Prepare and present a comprehensive project report with effective demonstration of outcomes.

SYLLABUS	**25 Hrs.**

Implementation of the proposed methodology or system design, development of prototype/model/software solution for robotics and AI domain. Which may involves experimentation and data collection, performance evaluation and validation of results, analysis and interpretation of outcomes, optimization and refinement of the system, comparison with existing methods, preparation of detailed project report, documentation of results, and final presentation with demonstration of the working model or system.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>26ES03PR0508</td><td colspan="4">Robot Operating Systems (ROS)</td><td>PCC</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">FE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>P</td><td>S</td></tr>
<tr><td>00</td><td>02</td><td>01</td><td>50</td><td>00</td><td>01</td></tr>
<tr><td colspan="6">Prerequisite: C++/Python Programming, Fundamentals of Robotics</td></tr>
<tr><td colspan="6">Course Objectives:
1. To introduce the structure and components of Robot Operating System (ROS).
2. To develop ROS nodes for robotic applications using publishers and subscribers.
3. To integrate ROS with sensors, actuators, and simulation tools.
4. To implement SLAM, path planning and control using ROS packages.</td></tr>
<tr><td colspan="6">Course Outcomes: On successful completion of the module students will be able to:
CO1. Understand the architecture of ROS and its communication model.
CO2. Develop nodes, topics, services and actions in ROS using Python/C++.
CO3. Simulate robots using Gazebo and RViz.
CO4. Interface ROS with sensors and actuators.
CO5. Implement localization, mapping and path planning in ROS environment.</td></tr>
<tr><td colspan="5">UNIT I: Introduction to ROS</td><td>09 Hrs.</td></tr>
<tr><td colspan="6">Definition, need, components of IIoT, industrial automation and Industry 4.0, IIoT architecture. Discuss key drivers and benefits of IIoT, examples from smart factories, oil and gas, and energy sectors.</td></tr>
<tr><td colspan="5">UNIT II: ROS Programming Basics</td><td>09 Hrs.</td></tr>
<tr><td colspan="6">Smart sensors, wired and wireless protocols (Modbus, ZigBee, BLE, LoRa, MQTT), sensor interfacing. Deep dive into sensor characteristics, calibration, interfacing techniques, usecases of LoRa, MQTT, and BLE in industry.</td></tr>
<tr><td colspan="5">UNIT III: Visualization and Simulation</td><td>9 Hrs.</td></tr>
</table>

Edge devices, gateways, data preprocessing, cloud platforms (AWS, Azure, Google Cloud) for IIoT. Edge analytics frameworks, data fusion, Fog computing, cloud architecture patterns and deployment models.	
UNIT IV: Interfacing Sensors and Actuators	**9 Hrs.**
Data acquisition, storage, visualization, analytics using ML for predictive maintenance and fault detection. Database technologies for IIoT, timeseries databases, data cleaning, dashboards and analytics pipelines.	
UNIT V: SLAM and Navigation	**9 Hrs.**
Cybersecurity in IIoT, encryption techniques, standards, industrial usecases and IIoT in robotics. Cyber threats in IIoT, intrusion detection systems, usecase studies from automotive, healthcare, and logistics.	

TEXT BOOKS:

- Jason O'Kane, 'A Gentle Introduction to ROS', CreateSpace Independent Publishing.
- Morgan Quigley, Brian Gerkey, William D. Smart, 'Programming Robots with ROS', O'Reilly.

REFERENCE BOOKS:

- Aaron Martinez, Enrique Fernandez, 'Learning ROS for Robotics Programming', Packt Publishing.
- ROS Wiki: http://wiki.ros.org

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS05TP0501	**Business Communication**				AEC
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
01	02	01	50	50	02

Prerequisite: None

Course Objectives:

1. To enhance students' communication and presentation skills.
2. To introduce professional writing formats used in industry.
3. To prepare students for group discussions and interviews.
4. To develop team and leadership communication skills.

Course Outcomes: On successful completion of the module students will be able to:

CO1. Communicate effectively in professional and academic contexts.

CO2. Draft business letters, emails, and technical reports.

CO3. Demonstrate skills in group discussion and presentations.

CO4. Apply interpersonal communication in team settings.

UNIT I: Fundamentals of Deep Learning	**09 Hrs.**

Types of communication, communication process, barriers, and overcoming them. Nonverbal cues, communication channels, intercultural communication, formal vs informal styles.

UNIT II: Convolutional Neural Networks	**09 Hrs.**

Email etiquette, report writing, proposals, technical documentation. Business proposals, circulars, notices, resumes, agendas and minutes of meetings.

UNIT III: Recurrent Neural Networks	**9 Hrs.**

Presentations, body language, voice modulation, confidence building. Handling Q&A, managing stage fear, using visual aids effectively in presentations.

UNIT IV: Generative Models	**9 Hrs.**

Mock GDs, interview strategies, frequently asked questions, STAR approach. Types of interviews, handling stress interviews, structured vs unstructured GD formats.

UNIT V: Applications and Tools	**9 Hrs.**

Workplace communication, teamwork, leadership skills, time and stress management. Emotional intelligence, worklife balance, conflict resolution, peer communication.

TEXT BOOKS:

- Meenakshi Raman & Sangeeta Sharma, 'Technical Communication', Oxford University Press.
- Raymond V. Lesikar, Marie E. Flatley, Kathryn Rentz, 'Business Communication', McGrawHill.

REFERENCE BOOKS:

- P. D. Chaturvedi, 'Business Communication: Concepts, Cases and Applications', Pearson Education.
- Sharon Gerson, Steven Gerson, 'Technical Communication Process and Product', Pearson.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

Semester-VI

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

SEMESTER VI					
Course Code	**Course Title**				**Category**
26ES03TH0601	**Robot safety, maintenance and standards**				PCC
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
02	0	1	50	50	**02**

Prerequisites

Students should have:

1. Basic understanding of robotics and automation systems.
2. Knowledge of engineering mechanics and machine elements.
3. Familiarity with electrical and electronic components used in robots.
4. Basic understanding of control systems and sensors.

Course Objectives

After completing this course, students will be able to:

1. Understand **s**afety principles, hazards, and risk assessment in robotic systems.
2. Apply industrial safety standards and regulatory requirements.
3. Develop knowledge of maintenance strategies and troubleshooting techniques.
4. Analyse reliability, failure modes, and lifecycle safety of robotic systems.

Course Outcomes (CO)

After successful completion of the course, students will be able to:
CO1: Identify and assess hazards and risks in robotic systems and work environments.
CO2: Apply relevant robot safety standards and compliance requirements.
CO3: Plan and perform maintenance, diagnostics, and troubleshooting of robotic systems.
CO4: Analyze reliability, failure modes, and implement safe lifecycle practices.

Unit I: Robot Safety Fundamentals and Risk Assessment	**07 Hrs.**

Importance of safety in robotics and automation, Types of hazards: mechanical, electrical, thermal, environmental, Risk assessment techniques and hazard identification, Safety in human-robot interaction (HRI), Workspace design: safety zones, guarding, interlocks.

Unit II: Safety Standards and Regulatory Compliance	**07 Hrs.**

Overview of international standards (ISO, ANSI, IEC), Key standards: ISO 10218 (industrial robot safety), ISO/TS 15066 (collaborative robots), Machine safety directives and compliance procedures, Certification, documentation, and legal considerations.

Unit III: Maintenance and Diagnostics of Robotic Systems	**07 Hrs.**
Types of maintenance: preventive, predictive, corrective, Maintenance planning and scheduling, Inspection, lubrication, and calibration, Condition monitoring and fault diagnostics, Troubleshooting techniques	
Unit IV: Reliability, Failure Analysis and Safety Integration	**07 Hrs.**
Reliability concepts (MTBF, MTTR), Failure modes and effects analysis (FMEA), Root cause analysis and risk mitigation, Fail-safe design and emergency systems, Safety integration in robotic cells and lifecycle management, Case studies of industrial robot safety	

Textbooks:

1. Dhillon, B.S., Robot System Reliability and Safety: A Modern Approach, CRC Press, 2015.
2. Starr, J. & Quick, C., Robotic Safety Systems: An Applied Approach, CRC Press, 2024.

Reference Books

1. Etherton, J.R., Safe Maintenance Guide for Robotic Workstations, DIANE Publishing, 1994.
2. Nof, S.Y., Handbook of Industrial Robotics, Wiley.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0602	**Robotic Vision System**				PCC
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
03	02	01	50+50	50	04

Prerequisite: Fundamentals of Robotics, Basic Image Processing, Linear Algebra, C Programming

Course Objectives:

1. To understand the principles of image formation and perception in robotics.
2. To apply image processing techniques to robotics tasks.
3. To study stereo vision, object detection, and segmentation for robotic perception.
4. To develop algorithms for feature extraction, classification, and scene interpretation.
5. To integrate vision systems with robotic manipulators and mobile platforms.

Course Outcomes: On successful completion of the module students will be able to:

CO1. Understand the fundamentals of robotic vision and image sensing.
CO2. Apply techniques such as filtering, edge detection, and thresholding.
CO3. Analyze stereo vision and depth estimation for robot navigation.
CO4. Implement object detection, tracking, and feature-based matching.
CO5. Integrate robotic vision with perception and control tasks in real-time.

UNIT I: INTRODUCTION TO ROBOTIC VISION	**09 Hrs.**
Introduction to robot vision and applications, Components of vision system (camera, sensors, optics), Image formation and acquisition, Digital image representation (pixels, resolution, color models)	
UNIT II: IMAGE PROCESSING FUNDAMENTALS	**09 Hrs.**
Image histograms and intensity distribution, Histogram contrast enhancing, Histogram scaling shifting and equalization , Image filtering (smoothing, sharpening), Histogram specification	
UNIT III: GEOMETRIC TRANSFORMATION AND MAPPING	**09 Hrs.**
Coordinate systems and homogeneous coordinates, Translation, rotation, scaling, Affine transformation (properties and applications), Homography and perspective transformation, Direct Linear Transformation (DLT)	
UNIT IV: CAMERA MODELS AND 3D VISION	**9 Hrs.**
Pinhole camera model, Camera projection equation, Intrinsic and extrinsic parameters, Camera calibration techniques, 3D to 2D mapping and reconstruction basics	
UNIT V: VISION-BASED CONTROL AND APPLICATIONS	**9 Hrs.**
Visual servoing, SLAM overview, object tracking, vision-guided pick and place, ROS integration, real-world case studies, Visual SLAM, EKF SLAM, 2-D LiDAR SLAM, Factor Graph (Multi-Sensor SLAM Framework), Pose Graphs	

TEXT BOOKS:

[1] Szeliski, R. (2021). *Computer vision: Algorithms and applications* (2nd ed.). Springer.
[2] Corke, P., 'Robotics, Vision and Control: Fundamental Algorithms in MATLAB', Springer.
[3] Szeliski, R., 'Computer Vision: Algorithms and Applications', Springer.

REFERENCE BOOKS:

[1] Gonzalez, R. C., Woods, R. E., 'Digital Image Processing', Pearson.
[2]Simon J. D. Prince, 'Computer Vision: Models, Learning, and Inference', Cambridge University Press.

Lab Experiments: Robot Vision Systems

1. Analyze and perform histogram scaling and shifting using MATLAB (including histogram plotting)
2. Implement histogram equalization for image contrast enhancement using MATLAB
3. Apply histogram specification (histogram matching) using MATLAB
4. Perform geometric image transformations (rotation, scaling, affine, and perspective/homography) using MATLAB
5. Estimate stereo disparity for depth computation using MATLAB
6. Implement SLIC (Simple Linear Iterative Clustering) segmentation using MATLAB with interactive GUI features
7. Perform image registration using MATLAB
8. Implement visual simultaneous localization and mapping (vSLAM) with visual-inertial sensor fusion using a monocular camera
9. Implement feature-based visual SLAM with visual-inertial sensor fusion using an RGB-D camera.
10. Implement feature-based visual SLAM with visual-inertial sensor fusion using a stereo camera

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0603	Deep Learning				Professional Core
Contact Hours per Week			CA	ESE	Credits
L	T	D/P			
03	02	00	50 + 50	50	04

Prerequisite: Introduction to Python, Machine Learning Concepts

Course Objectives:

1. To provide a strong foundation in deep learning concepts, architectures, and algorithms for solving complex real-world problems.
2. To develop practical skills in implementing deep learning models using modern frameworks for applications such as image processing, sequence modeling, and predictive analytics.

Course Outcomes: On successful completion of the module students will be able to:
CO1: Understand fundamental concepts of neural networks and deep learning architectures.
CO2: Apply deep learning techniques for classification and regression problems.
CO3: Analyze and implement convolutional and recurrent neural networks for real-world applications.
CO4: Evaluate and optimize deep learning models using appropriate techniques.
CO5: Design and develop end-to-end deep learning solutions for practical problems.

UNIT I: Introduction to Deep Learning and Neural Networks	**09 Hrs.**

Machine Learning vs Deep Learning, biological neuron vs artificial neuron, perceptron model, multilayer perceptron (MLP), activation functions (sigmoid, ReLU, tanh), loss functions, gradient descent and variants, forward propagation, backpropagation algorithm, challenges in training deep networks (vanishing gradient, overfitting), introduction to TensorFlow and Keras.

UNIT II: Deep Feedforward Networks and Optimization Techniques	**09 Hrs.**

Deep feedforward networks, weight initialization techniques, regularization (L1, L2, dropout), batch normalization, optimization algorithms (SGD, Adam, RMSProp), hyperparameter tuning, model evaluation metrics.

UNIT III: Convolutional Neural Networks (CNNs)	**9 Hrs.**

Introduction to CNN, convolution operation, pooling layers, padding and stride, feature maps, CNN architectures, transfer learning, image classification, object detection basics, applications in computer vision

UNIT IV: Recurrent Neural Networks (RNNs) and Sequence Models	**9 Hrs.**

Sequence data and time series, recurrent neural networks, vanishing gradient problem in RNN, Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), bidirectional RNN, sequence-to-sequence models.

UNIT V: Advanced Deep Learning and Applications	**9 Hrs.**

Autoencoders, Generative models (GANs), transformers basics, deep learning for reinforcement learning, model deployment basics.

TEXT BOOKS:

Pattern Recognition and Machine Learning by Christopher M. Bishop – A comprehensive guide to

statistical pattern recognition and machine learning with a strong mathematical foundation.
Machine Learning by Tom M. Mitchell – A classic introductory book covering key ML algorithms with intuitive explanation.

REFERENCE BOOKS:

1. Deep Learning – Ian Goodfellow, Yoshua Bengio, Aaron Courville
2. Neural Networks and Deep Learning – Charu C. Aggarwal
3. Deep Learning with Python – François Chollet
4. Pattern Recognition and Machine Learning – Christopher M. Bishop
5. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow – Aurélien Géron
6. Machine Learning Yearning – Andrew Ng

List of Experiment

1. Build and train a Multilayer Perceptron (MLP) for classification.
2. Experiment with different activation functions and compare performance.
3. Implement gradient descent and visualize loss convergence.
4. Build and train a CNN for image classification (Project Based).
5. Implement transfer learning using pre-trained CNN models.
6. Visualize feature maps in CNN.
7. Implement RNN for sequence prediction.
8. Build LSTM model for time series forecasting.
9. Implement GRU and compare it with LSTM performance.
10. Develop an autoencoder for dimensionality reduction.
11. Implement a simple GAN for image generation.
12. Develop an end-to-end deep learning project (problem definition, preprocessing, model building, evaluation).
13. Perform model tuning, evaluation, and optimization.

Course Code	Course Title	Category
26ES03TH0604	**Mobile Robotics** **Semester VI**	**PCC**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Contact Hours per Week			CA	ESE	Credits
L	P	Total			
02	00	**02**	50	50	02

Prerequisite: Basics of Robotics, Engineering Mathematics (Matrices, Probability basics)

Course Description: This course introduces the fundamentals of robotics with an emphasis on mobile robots, which are integrated mechanical, electrical and computational systems functioning in the physical world. The course aims to provide both theoretical and practical experience to students through lectures and hands-on experiments with real robots and simulation software.

Course Objectives: This course will present various aspects of design, fabrication, motion planning, and control of intelligent mobile robotic systems.

1. To introduce fundamentals of mobile robots, locomotion, and hardware components.
2. To develop understanding of kinematics, dynamics, and motion constraints.
3. To provide knowledge of perception, sensing, and uncertainty handling.
4. To explain localization, mapping, and navigation techniques.
5. To expose students to path planning algorithms and intelligent robot design.

Course Outcomes: On successful completion of the module students will be able to:
CO1. *Explain* mobile robot types, locomotion mechanisms, and performance characteristics.
CO2. *Apply* kinematic and dynamic models to analyze motion of mobile robots.
CO3. *Analyze* sensor characteristics and perception techniques under uncertainty.
CO4. *Apply* localization methods to estimate robot position in uncertain environments.
CO5 *Evaluate* path planning and navigation algorithms for intelligent mobile robots.

UNIT I: FUNDAMENTALS OF MOBILE ROBOTICS **06 Hrs.**

Introduction to mobile robots, classification (wheeled, legged, aerial). Applications in industrial and service domains. Locomotion principles,Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability, degrees of freedom, holonomic and non-holonomic systems. Overview of robot components: sensors, actuators, controllers.

UNIT II: KINEMATICS OF MOBILE ROBOTS **06 Hrs.**

Kinematic modeling of wheeled mobile robots: differential drive and car-like robots. Coordinate frames and transformations, robot pose representation. Forward kinematics and basic motion constraints. Odometry and dead reckoning.

UNIT III: PERCEPTION **06 Hrs.**

Sensors Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision-based sensors, uncertainty in sensing, filtering.

UNIT IV: LOCALIZATION **06 Hrs.**

Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems;

UNIT V: PATH PLANNING AND NAVIGATION **07 Hrs.**

Introduction, Path Planning, offline and online path planning, obstacle avoidance, path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), Potential field etc.

Advanced Topics: AI based techniques for navigation, Bio Inspired Algorithm, Multiple robot coordination. Design of intelligent robots
TEXT BOOKS: 1. Siegwart, Nourbakhsh, Scaramuzza – *Introduction to Autonomous Mobile Robots* 2. Dudek & Jenkin – *Computational Principles of Mobile Robotics*
REFERENCE BOOKS: Thrun, Burgard, Fox – *Probabilistic Robotics* Howie Choset – *Principles of Robot Motion* *Selected readings from the research literature, to be distributed in class.*

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>26ES03PR0608</td><td colspan="4">Project-I</td><td>Project</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td rowspan="2">CA</td><td rowspan="2">ESE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>P</td><td>S</td></tr>
<tr><td>00</td><td>04</td><td>00</td><td>50</td><td></td><td>02</td></tr>
<tr><td colspan="6">Prerequisite: Introduction to Python, Machine Learning Concepts</td></tr>
<tr><td colspan="6">Course Objectives:
1. To expose students to real-world engineering problems through industry-linked projects.
2. To develop problem-solving, design, and implementation skills using modern tools and technologies.</td></tr>
<tr><td colspan="6">Course Outcomes: On successful completion of the module students will be able to:
CO1: Identify and define real-world engineering problems in collaboration with industry.
CO2: Apply engineering knowledge and tools to design feasible solutions
CO3: Analyze data and interpret results for problem-solving.
CO4: Demonstrate teamwork, project planning, and communication skills
CO5: Design and develop end-to-end deep learning solutions for practical problems.</td></tr>
<tr><td colspan="6">Problem identification from industry domain, Literature survey, Problem definition and objective setting, Requirement analysis, Concept generation and design, Selection of methodology, Modeling and simulation (if applicable), Prototype development or implementation, Testing and validation, Data analysis and result interpretation, Documentation and report writing, Presentation and demonstration.</td></tr>
</table>

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

Semester-VII

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

SEMESTER VII					
Course Code	**Course Title**				**Category**
26ES03TP0701	**Mechanical Design of Robotic System**				PPC
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**S**			
02	02	1	50 + 50	50	**03**

Prerequisites:
Students should have:

- Basic knowledge of Engineering Mechanics (forces, equilibrium, stress–strain).
- Understanding of Strength of Materials (deformation, bending, torsion).
- Familiarity with Theory of Machines/Kinematics of Mechanisms.
- Basic knowledge of materials science and manufacturing processes.

Course Objectives:
After completing this course, students will be able to:

1. Understand the **structural and mechanical design requirements** of robotic systems.
2. Apply principles of **material selection and manufacturing** in robotic component design.
3. Analyze and design **joints, transmission systems, and actuating mechanisms**.
4. Evaluate and design **end effectors and gripping systems** for various robotic applications.

Course Outcomes:
After successful completion of the course, students will be able to:

1. Analyze mechanical structures of robotic manipulators considering strength, stiffness, and dynamic effects.
2. Select appropriate materials and manufacturing techniques for efficient and lightweight robotic designs.
3. Design and evaluate robotic joints and transmission systems based on performance and efficiency.
4. Perform force analysis and design of end effectors suitable for different industrial and service applications.

UNIT I: Fundamentals of Robotic Mechanical Design	**07 Hrs.**

Structural requirements of robotic manipulators: rigidity, stability, and precision, Design criteria: stiffness, strength, weight optimization, natural frequency, payload capacity, Static vs dynamic loading in robotic arms (impact, inertia, cyclic loading), Structural design vs kinematic design, Geometric considerations in link design (cross-sections, slenderness ratio), Application of beam theory and torsion theory in robotic links, Mass distribution and centre of gravity effects on stability and control, Deformation and deflection analysis under loading conditions, Vibration and resonance considerations in robotic structures, Fatigue analysis and failure modes in repetitive robotic operations

UNIT II: Material Selection and Manufacturing Considerations	**07 Hrs.**

Criteria for material selection: strength-to-weight ratio, stiffness, durability, cost, Mechanical properties: yield strength, modulus of elasticity, toughness, fatigue strength, Advanced materials: Composites (carbon fiber, glass fiber), Lightweight alloys (aluminium, titanium), Introduction to additive manufacturing (3D printing) for robotic components, Surface treatment and coatings for wear and corrosion resistance, Design for manufacturability (DFM) and design for assembly (DFA) principles.

UNIT III: Joints and Transmission Systems	**07 Hrs.**

Design of joints: revolute, prismatic, spherical joints, Bearings: types (ball, roller, plain), selection and load considerations, Couplings: rigid and flexible couplings and their applications, Role and requirements of Power transmission in robotic systems, Gear systems: Spur, helical, bevel, and planetary gears, Gear ratio design and torque transmission, Backlash, wear, and efficiency considerations, Belt and chain drives: Kinematics and velocity ratios, Tension analysis and slip conditions, Lead screws and ball screws: efficiency and precision,

UNIT IV: Force Analysis of End Effectors	**07 Hrs.**

Role and classification of end effectors in robotics, Force transmission mechanisms in grippers, Gripping force calculation and safety factors, Contact mechanics and friction in gripping, Structural design of gripper arms and fingers, Design of frames, fixtures, and holding mechanisms, Material and topology selection for different applications.

TEXT BOOKS:

1. Budynas, R.G. & Nisbett, J.K., *Shigley's Mechanical Engineering Design*, McGraw-Hill, 11th/12th Ed.
2. **Robert L. Norton, Machine Design: An Integrated Approach,** 6th Edition, Pearson Education
3. Eugene I. Rivin, **Mechanical Design of Robots,** McGraw-Hill, 1st Edition

Reference Book:

1. Vigen (Vladimir) S. Arakelian, **Dynamic Decoupling of Robot Manipulators,** 1st Edition (2018), Springer International Publishing (Springer, Cham), Mechanisms and Machine Science, Vol. 56, **ISBN:** 978-3-319-74362-2 (Hardcover), 978-3-319-74363-9 (eBook)
2. Springer Handbook of Robotics, Editors: Bruno Siciliano, Oussama Khatib, Edition: 2nd Edition (2016), Publisher: Springer
3. Richard D. Klafter, Thomas A. Chmielewski, Michael Negin, Robotic Engineering: An Integrated Approach, (Mechanical Design Sections), Publisher: Prentice Hall
4. Siciliano, B. & Khatib, O., *Springer Handbook of Robotics*, Springer, 2nd Ed., 2016.

List of Experiments

1. Study of Different Types of Robotic Configurations
2. Design and Analysis of Robotic Arm Links
3. Forward Kinematics of Robotic Manipulator
4. Inverse Kinematics of Robotic Manipulator
5. Design of Robotic Gripper Mechanism
6. Torque Calculation and Motor Selection for Robot Joints
7. CAD Modeling of Robotic Arm
8. Finite Element Analysis of Robot Components
9. Design of Gear Train for Robotic Systems
10. Design of Belt and Chain Drives in Robots
11. Design and Analysis of End Effectors
12. Workspace Analysis of Robotic Manipulator
13. Dynamic Analysis of Robotic Arm
14. Design of Mobile Robot Chassis

Course Code	**Course Title**		**Category**
26ES03TH0702	**Agentic AI**		PCC
Contact Hours per Week	**CA**	**ESE**	**Credits**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

L	P	S			
02	02	1	-	-	**03**

Course Objectives:
After completing this course, students will be able to:
1. To understand the design and functioning of intelligent autonomous agents, including perception, reasoning, and decision-making.
2. To develop agent-based systems using modern AI technologies such as Transformers, Large Language Models (LLMs), and Retrieval-Augmented Generation (RAG).

Course Outcomes:
After successful completion of the course, students will be able to:
CO1: Explain the fundamentals of intelligent agents and agent architectures.
CO2: Apply search and planning techniques in agent decision-making.
CO3:Analyze reasoning and learning mechanisms in intelligent agents.
CO4: Evaluate LLM-based agents and their capabilities.
CO5: Develop simple agentic AI applications using modern tools and frameworks

Unit 1:Introduction to Agentic AI **08 Hrs.**

Introduction to Artificial Intelligence, Intelligent agents and environments, Types of agents (simple reflex, model-based, goal-based, utility-based), Rational agents, PEAS representation, Agent memory and decision making, Applications of Agentic AI

Unit 2: Natural Language Processing and Text Understanding **09 Hrs.**

Introduction to Natural Language Processing (NLP), Text preprocessing, Tokenization, Stop-word removal, Stemming and Lemmatization, Word embeddings (basic idea), Text classification, Applications of NLP

Unit 3: Transformers and Large Language Models **09rs.**

Transformer architecture, Attention mechanism, Pre-trained models, Multi perceptron Neural Network, Large Language Models (LLMs),

Unit 4: Prompt Engineering and Agentic Systems **08 Hrs.**

Prompt engineering techniques, Context handling, Memory in AI agents, Tool-using agents, Autonomous agents, Hallucination and limitations of LLMs, AI agent workflows and reasoning

Unit 5:RAG and Multi-Agent Systems **09 Hrs**

Retrieval-Augmented Generation (RAG), Vector databases (conceptual), Knowledge retrieval, Multi-agent systems, Agent communication and coordination, Applications in chatbots, robotics, automation, and intelligent assistants

TEXT BOOKS:
1. Multi-Agent Systems: Algorithmic, Game-Theoretic, and Logical Foundations — Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press

Reference Book:
1. Deep Learning — Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press
2. Multi-Agent Systems — Michael Wooldridge, Wiley
3. Machine Learning — Tom M. Mitchell, McGraw-Hill Education

List of experiments:

1. Study of Python libraries for AI and NLP (NLTK, Transformers) & Hardware understanding required for LLM.
2. Text preprocessing: tokenization, stop-word removal, stemming and lemmatization
3. Text classification using basic NLP techniques
4. Word embedding and semantic similarity analysis
5. Introduction to Hugging Face Transformer models
6. Text generation using pre-trained Transformer models
7. Prompt engineering techniques using LLM tools
8. Development of a simple chatbot using LLM APIs
9. Implementation of memory-based AI agent
10. Building a Retrieval-Augmented Generation (RAG) pipeline
11. Development of tool-using autonomous agents
12. Mini Project: Agentic AI application for automation, chatbot, or intelligent assistance

Course Code	Course Title	Category

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

26ES03PR0703	**Project-II**				Project
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**S**			
00	08	00	50	50	04

Prerequisite: Introduction to Python, Machine Learning Concepts

Course Objectives:

3. To expose students to real-world engineering problems through industry-linked projects.
4. To develop problem-solving, design, and implementation skills using modern tools and technologies.

Course Outcomes: On successful completion of the module students will be able to:

CO1: Identify and define real-world engineering problems in collaboration with industry.
CO2: Apply engineering knowledge and tools to design feasible solutions
CO3: Analyze data and interpret results for problem-solving.
CO4: Demonstrate teamwork, project planning, and communication skills
CO5: Design and develop end-to-end deep learning solutions for practical problems.

Problem identification from industry domain, Literature survey, Problem definition and objective setting, Requirement analysis, Concept generation and design, Selection of methodology, Modeling and simulation (if applicable), Prototype development or implementation, Testing and validation, Data analysis and result interpretation, Documentation and report writing, Presentation and demonstration.

Course Code	**Course Title**	**Category**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

26ES03PR0704	**Comprehensive Viva**				PCC
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
00	02	01	50	00	01

Prerequisite: All previous core subjects till Semester IV

Course Objectives:

1. To assess the student's overall understanding of core subjects learned so far.
2. To develop the ability to articulate and defend technical concepts in oral format.
3. To prepare students for technical interviews and examinations.

Course Outcomes: On successful completion of the module students will be able to:

CO1. Demonstrate understanding of key concepts from previous semesters.
CO2. Communicate effectively using appropriate technical language.
CO3. Display confidence and clarity during oral evaluations.
CO4. Apply interdisciplinary knowledge in solving problems.

Syllabus

The Comprehensive Viva will cover the contents from the courses, both the theory and the lab practice which the student learnt during third to sixth semester of the undergraduate programme.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

B.Tech. Robotics and Artificial Intelligence

Programme Syllabus

Semester-VIII

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

SEMESTER VIII					
Course Code	**Course Title**				**Category**
26ES03TH0801	**Project Management**				**PCC**
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**S**			
03	**00**	**01**	**50**	**50**	**03**

Prerequisite: Robotics fundamentals

Course Objectives:

The Objectives of this course is;

1. To provide an understanding of project planning, scheduling, and execution.
2. To equip students with knowledge of project cost, time, and resource management.
3. To develop the ability to manage risk and quality within projects.
4. To introduce tools and techniques for effective project monitoring and control.
5. To build competency in handling industrial, research, and service-based projects.

Course Outcomes: On successful completion of the module students will be able to:

CO1: Describe the fundamentals, phases, and types of project management.

CO2: Develop detailed project plans including scope, schedule, and resources.

CO3: Analyze project cost, budgeting, and risk factors using standard techniques.

CO4: Apply quality control and risk mitigation strategies during execution.

CO5: Monitor and evaluate project performance using project management tools.

UNIT I: INTRODUCTION TO PROJECT MANAGEMENT	**06 Hrs.**
Definition of project and project management, Project life cycle phases, Types of projects, Characteristics of successful projects, Role of project manager, Project selection methods, Feasibility analysis, Project charter, Organizational structures, Project stakeholders, Ethics in Project Management	
UNIT II: PROJECT PLANNING AND SCHEDULING	**06 Hrs.**
Project scope definition, Work Breakdown Structure (WBS), Project time management, Gantt chart, Network diagrams, Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Milestone planning, Time-cost trade-offs, Resource allocation and levelling, AI tools in project planning	
UNIT III: PROJECT COSTING AND BUDGETING	**06 Hrs.**
Cost estimation techniques, Project budgeting methods, Cost baseline, Earned Value Management (EVM), Project cash flows, Financial analysis: NPV, IRR, Payback period, Break-even analysis, Cost control methods	
UNIT IV: PROJECT QUALITY AND RISK MANAGEMENT	**06 Hrs.**
Project quality planning, Quality assurance and control, Six Sigma in project management, Risk identification and classification, Qualitative and quantitative risk analysis, Risk response planning, Contingency planning, Risk monitoring and control, Lifecycle assessment and Environmental impact assessment.	

UNIT V: PROJECT MONITORING, CONTROL, AND CLOSURE	**06 Hrs.**
Monitoring and control processes, Key performance indicators (KPIs), Project audits, Conflict resolution, Change management, Generative AI for documentation & reporting, Project evaluation and termination, Post-project review, Lessons learned, Project management software tools (MS Project, Power BI, Primavera)	

TEXT BOOKS:

Harold Kerzner – *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, Wiley

REFERENCE BOOKS

1. P. Gopalan – Project Management, Wiley India
2. S. Choudhury – Project Management, Tata McGraw Hill
3. Rory Burke – Project Management: Planning and Control Techniques, Wiley
4. Prasanna Chandra – Projects: Planning, Analysis, Selection, Financing, Implementation and Review, McGraw Hill
5. PMI – A Guide to the Project Management Body of Knowledge (PMBOK® Guide), Project Management Institute

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TH0802	Research Methodology				PCC
Contact Hours per Week			CA	ESE	Credits
L	P	S			
2	0	1	50	50	02

Prerequisite:
Basic understanding of undergraduate-level subjects, fundamental mathematics/statistics, and general academic writing skills. Familiarity with computers and basic research concepts will be helpful.

Course objectives:
Students should be able
1. To introduce the fundamentals of research methodology, research process, and techniques of scientific inquiry.
2. To develop skills in identifying research problems, reviewing literature, and designing research methodology.
3. To familiarize students with various methods of data collection, analysis, and interpretation.
4. To create awareness about ethics in research paper writing
5. To enable students to understand Intellectual Property Rights (IPR), patents, copyrights, its evolution, significance and their applications in innovation.

Course Outcomes:
At the end of the course the student will be able to:
CO1: Understand the basic concepts, process, and importance of research methodology in academic and industrial research.
CO2: Formulate research problems, conduct literature reviews, and prepare structured research proposals.
CO3: Apply suitable methods of data collection, analysis, and interpretation to solve research problems.
CO4: Choose research topics, write structured research papers and adhere to plagiarism rules and ethical standards.
CO5: Understand the procedures for patent filing, copyright, and trademark registration, and apply IPR concepts in real-life case studies.

COURSE CONTENTS

UNIT I: INTRODUCTION TO RESEARCH METHODOLOGY	**08 hours**

Meaning of Research, How to do Research, Objective of Research, Motivation in Research, Types of Research, Various Research Approaches and Significance of Research. Research Methods and Research Methodology.

UNIT II: RESEARCH PROBLEM AND LITERATURE REVIEW	**07 hours**

Research Problem, Various Components of Research Problem, How to Identify the Research Problem, Necessity and Techniques involved in Defining Research Problem, Feasibility Check. Meaning and

Importance of Literature Review, Sources of literature, Role in identifying Research Gaps and Framing Research Problem.

UNIT III: DATA COLLECTION AND ANALYSIS	**07 hours**

Hypothesis, its Characteristics, Examples, Types, Hypothesis Testing, Concepts and Procedure of Hypothesis Testing. Data Collection, Methods of data collection, Primary Data, Secondary Data, Analysis of data, Simple regression, Multiple regression, linear and non-linear correlation and regression.

Unit IV: Ethics in Research	**07 hours**

Research Paper and its contents, Choice on topic, Method of writing research paper, Ethics in Research, Plagiarism including rules of Plagiarism. Citation and Referencing Styles, Structure of a Research Report/Paper. Case studies of Research Papers in Science and Engineering. Presentation of Research Work.

Unit V: Introduction to Intellectual Property Rights (IPR)	**07 hours**

Introduction to IPR, Types of IPR, Common rules of IPR Practices, Patent Filing Procedure and Licensing Process. Case studies of Patents in Science and Engineering.

Text Books:

1. Research Methodology Methods and Techniques: Kothari C.K. (2004), New Age International, New Delhi
2. Simulation Modeling and Analysis, Law, A. M., and W. D. Kelton, 1991, McGraw Hill
3. Applied Statistics; Probability for Engineers: Montgomery, Douglas C.; Runger, George C. (2007), (Wiley India)
4. Patents myths and reality, Shiva, V., Penguin Books India (P) Ltd., New Delhi

Reference Books:

1. Schaum's Quick Guide to Writing Great Research Papers: Laurie Rozakis, 2nd edition, McGraw.
2. Intellectual Property Rights:Text And Cases, Radhakrishnan , R. &Balsubramaian, S., Excel Books Publishers, New Delhi.
3. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2012.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", December 2018.

Course Code	**Course Title**	**Category**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

26ES03PR803	**Project III**				Project
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
00	12	01	50	50	06

Prerequisite: All previous core subjects till Semester IV

Course Objectives:

1. To implement and validate the proposed engineering solution for a real-world problem.
2. To develop professional skills in design, experimentation, analysis, documentation, and presentation through pro execution.

Course Outcomes: On successful completion of the module students will be able to:

CO1. Implement the proposed methodology for solving an engineering problem

CO2. Analyze and interpret experimental/simulation results

CO3. Develop a functional prototype, model, software, or validated solution

CO4. Demonstrate teamwork, project management, and professional ethics

CO5. Prepare technical documentation and effectively present project outcomes

Syllabus	**40 Hrs**

Detailed implementation of project work, Design and development of prototype/model/software, Expe investigation and testing, Simulation and validation, Data acquisition and analysis, Optimization and perf evaluation, Integration of hardware/software tools, Result interpretation, Technical documentation, Research pap preparation, Project presentation and demonstration.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26HS02TH0801	**Foundational Literature of Indian Civilization**				**IKS**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
01	**00**	**01**	**50**	**-**	**01**

Course Outcomes:

CO1: Understand the Indian knowledge system and its scientific approach
CO2: Get introduced to the Vedic corpus and recognize the multi-faceted nature of the knowledge contained in the Vedic corpus
CO3: Understand the salient features of the philosophical systems of the Vedic and non-Vedic schools
CO4: Develop an understanding about the foundation of Vedic Mathematics

Unit 1: Overview of Indian Knowledge System:	06 Hrs.
Importance of ancient knowledge, defining IKS, Historicity of IKS, Some unique aspects of IKS.	
Unit 2: The Vedic corpus:	06 Hrs.
Introduction of Vedas, four Vedas, divisions of four Vedas, six Vedangas, Distinct features of Vedic life.	
Unit 3: Indian Philosophical systems:	06 Hrs.
Development and unique features, Vedic schools of philosophy, Samkhya and Yoga School of philosophy, Nayay and Vaisesika school of philosophy, Purva-mimamsa and Vedanta schools of Philosophy, Non-vedic philosophies: Jainism, Buddhism, and other approaches	
Unit 4: Vedic Maths -1	06 Hrs.
Introduction of Vedic Mathematics, Bodhyan geometry, circular functions, inverse circular functions.	
Unit -5: Vedic Maths – 2	06 Hrs.
Multiplication of polynomials by nikhilaṃ and ūrdhvatiryagbhyām sutra. Verification by Gunitasamuccayaḥ. Division of two polynomials using parāvartya yojayet. HCF and LCM of two polynomials using ādyamādyenāntyamantyena and ānurūpyeṇa. Factorization of polynomials up-to degree 3 using ānurūpyeṇa, Lopanasthāpanābhyām, ādyamādyenāntyamantyena.	

Reference material

1. B. Mahadevan, Vinayak Rajat Bhar, Nagendra Pavana R. N., “Introduction to Indian Knowledge System: Concepts and Applications” PHI, 2022
2. S.C. Chatterjee and D.M. Datta, An introduction to Indian Philosophy, University of Calcutta, 1984

Program Specific Electives (PSE)

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><td colspan="6">Semester V</td></tr>
<tr><td>Course Code</td><td colspan="4">Course Title</td><td>Category</td></tr>
<tr><td>26ES03TH0504-1</td><td colspan="4">Bio-Inspired Robotics</td><td>PSE</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td>CA</td><td>FE</td><td>Credits</td></tr>
<tr><td>L</td><td>P</td><td>S</td><td></td><td></td><td></td></tr>
<tr><td>03</td><td>00</td><td>00</td><td>50</td><td>50</td><td>03</td></tr>
<tr><td colspan="6">Prerequisite: Fundamentals of Robotics</td></tr>
<tr><td colspan="6"><u>Course Objectives:</u>
1. To provide fundamental understanding of bioinspired sensing mechanisms and their applications in robotic systems.
2. To enable students to formulate bioinspired motion strategies by studying natural systems and translating them into robotic designs.
3. To develop the ability to differentiate between soft and hard robotics in terms of design principles, materials, and applications.
4. To analyze robotic control architectures and behaviours with specific reference to kinematics and system dynamics.
5. To evaluate concepts of collective and biohybrid robotics and apply them in the design and creation of electromechanical robotic systems.</td></tr>
<tr><td colspan="6"><u>Course Outcomes</u>
On successful completion of the module students will be able to:
1. Understand the Bioinspired sensing.
2. Formulate bioinspired motion
3. Differentiate Soft and Hard Robotics
4. Analyze control architecture and behavior with reference to kinematics
5. Evaluate collective and Biohybrid robotics/ create electromechanical robotic system</td></tr>
<tr><td colspan="6">COURSE CONTENTS</td></tr>
<tr><td colspan="5">UNIT 1: Introduction</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Fundamentals of Traditional Robots, Biologically-inspired Robots, Introduction, Bio-inspired morphologies, Bio-inspired sensors, Vision, Audition, Touch, Smell, taste, Idiothetic sensors.</td></tr>
<tr><td colspan="5">UNIT 2: Fundamentals of Biologically Inspired Robots</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Bio-inspired actuators, locomotion, crawling, walking, wall climbing, jumping, swimming, flying, grasping, drilling</td></tr>
<tr><td colspan="5">UNIT 3: Soft Robotics</td><td>08 Hrs.</td></tr>
</table>

Structural Difference between Hard and Soft Robots, Bio-inspiration in Soft Robotics, Hydrostatic Skeletons, Soft Robots, Actuators, Pneumatic Artificial Muscles, Electroactive Polymers, Shape Memory Alloys	
UNIT 4: Control architectures of Bio-inspired Robotics	**08 Hrs.**
Behaviour-based robotics, learning robots, evolving robots, developing robots, Bio-inspired Robot Design Considering Load-bearing and Kinematic Ontogeny of Sea Turtles	
UNIT 5: Case studies	**08 Hrs.**
Biohybrid robots. Case studies and Mini projects in Design and Fabrication of Biologically Inspired Robots	

Text Books

1. J.J. Craig. Introduction to Robotics: Mechanics and Control. Prentice Hall; 3rd edition, 2003

Reference Books

1. G. A. Bekey. Autonomous Robots. MIT Press, 2005.
2. Karl Williams. Amphibionics: Build Your Own Biologically Inspired Reptilian Robot. McGraw-Hill/TAB Electronics, 2003.
3. David Cook. Robot Building for Beginners. Apress, 2002.
4. Handbook of Robotics, Jean-Arcady Meyer and Agnès Guillot

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th colspan="6">Semester V</th></tr>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>26ES03TH0504-2</td><td colspan="4">Database Design and Management</td><td>PSE</td></tr>
<tr><th colspan="3">Contact Hours per Week</th><th>CA</th><th>ESE</th><th>Credits</th></tr>
<tr><th>L</th><th>T</th><th>P</th><th></th><th></th><th></th></tr>
<tr><td>03</td><td>00</td><td>00</td><td>50</td><td>50</td><td>03</td></tr>
<tr><td colspan="6">Prerequisite: Mechatronics, Engineering Mechanics, Basics of Electrical Engineering.</td></tr>
<tr><td colspan="6">Course Objectives:
1. To provide students with a strong foundation in database concepts, data models, relational theory, and database system architecture.
2. To develop the ability to design, implement, and manage efficient relational databases using ER modelling, SQL, normalization, and transaction management techniques.</td></tr>
<tr><td colspan="6">Course Outcomes: On successful completion of the module students will be able to:
1. Describe the purpose, architecture, components, and types of database management systems.
2. Model real-world applications using E–R and Extended E–R diagrams and transforms them into relational database schemas.
3. Apply the relational model, relational algebra, and SQL to define, manipulate, and retrieve data from relational databases.
4. Analyze transaction processing and concurrency control techniques to ensure data consistency, correctness, and recoverability.
5. Design normalized relational database schemas using dependency theory to minimize redundancy and improve data integrity.</td></tr>
<tr><td colspan="5">UNIT I: DATABASE SYSTEM FUNDAMENTALS</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Purpose and advantages of database systems, limitations of file systems, views of data, data abstraction, data models (hierarchical, network, relational, object-based), database architecture, database languages, storage management, transaction management overview, roles of database administrator and database users, overall database system structure, and types of database systems.</td></tr>
<tr><td colspan="5">UNIT II: ENTITY–RELATIONSHIP (E–R) MODELING</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Basic concepts of E–R model, entities and attributes, relationship types, constraints and mapping cardinalities, keys, weak entity sets, extended E–R features (specialization, generalization, aggregation), design issues, E–R diagrams, design of E–R database schema, and reduction of E–R schema to relational tables.</td></tr>
<tr><td colspan="5">UNIT III: RELATIONAL MODEL AND SQL</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Structure of relational databases, relational algebra operations, tuple and domain relational calculus, SQL overview, DDL and DML, set operations, aggregate functions, null values, nested and correlated sub-queries, derived relations, views, joins, constraints, and modification of database using SQL.</td></tr>
<tr><td colspan="5">UNIT IV: TRANSACTION MANAGEMENT AND CONCURRENCY CONTROL</td><td>08 Hrs.</td></tr>
</table>

Transaction concepts and states, ACID properties, atomicity and durability implementation, concurrent executions, serializability and recoverability, transaction definition in SQL, lock-based protocols, timestamp-based protocols, validation-based protocols, multiple granularity locking, multi-version concurrency control, deadlock handling, insert and delete operations, and concurrency in index structures.

UNIT V: RELATIONAL DATABASE DESIGN AND OPTIMIZATION	**08 Hrs.**

Pitfalls in relational database design, functional dependencies, normalization (1NF to BCNF), multivalued dependencies and 4NF, join dependencies and 5NF, domain-key normal form, decomposition techniques, lossless and dependency-preserving decomposition, query optimization basics, and overview of advanced database topics and applications.

TEXT BOOKS:

[1] Data base System Concepts, Silberschatz, Korth, McGraw hill, Sixth Edition.
[2] Data base Management Systems, Raghurama Krishnan, Johannes Gehrke, TATA McGrawHill 3rd Edition.

REFERENCE BOOKS:

[1] Fundamentals of Database Systems, ElmasriNavathe Pearson Education.
[2] An Introduction to Database systems, C.J. Date, A.Kannan, S.SwamiNadhan, Pearson, Eight Edition.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th colspan="6">Semester V</th></tr>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>26ES03TH0504-3</td><td colspan="4">Computer Aided Design</td><td>PCC</td></tr>
<tr><th colspan="3">Contact Hours per Week</th><th>CA</th><th>ESE</th><th>Credits</th></tr>
<tr><th>L</th><th>P</th><th>S</th><th></th><th></th><th></th></tr>
<tr><td>03</td><td>0</td><td>01</td><td>50</td><td>50</td><td>03</td></tr>
<tr><td colspan="6">Prerequisite: Fundamentals of Robotics, Basic Image Processing, Linear Algebra, C Programming</td></tr>
<tr><td colspan="6">Course Objectives:
1. To understand the principles of image formation and perception in robotics.
2. To apply image processing techniques to robotics tasks.
3. To study stereo vision, object detection, and segmentation for robotic perception.
4. To develop algorithms for feature extraction, classification, and scene interpretation.
5. To integrate vision systems with robotic manipulators and mobile platforms.</td></tr>
<tr><td colspan="6">Course Outcomes: On successful completion of the module students will be able to:
1. Understand CAD fundamentals, coordinate systems, and geometric representations.
2. Develop 3D part models and assemblies using parametric design concepts.
3. Prepare engineering drawings with proper dimensioning and tolerancing standards.
4. Apply CAD tools for design validation and integration with analysis tools.
5. Use CAD for product development considering manufacturability and data exchange.</td></tr>
<tr><td colspan="5">UNIT I: CAD FUNDAMENTALS</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Computer graphics fundamentals: Raster Scan Graphics, Coordinate systems, Transformations of Geometries, Homogeneous coordinate system, Composite transformations, Matrix representation of transformations, 3D transformation matrices, Product design cycle; CAD system components; coordinate systems; transformations,</td></tr>
<tr><td colspan="5">UNIT II: GEOMETRIC MODELLING and PART DRAWING</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Wireframe, surface, and solid modeling; parametric and feature-based modeling; Parametric Curves and Surfaces and their application in CAD, Introduction, Study and selection of machine component for part drawing based on actual machine components. Part Drawing from Assembly by incorporating manufacturing considerations: machining allowances, tolerances, and surface finish.</td></tr>
<tr><td colspan="5">UNIT III: MODELLING AND ASSEMBLY</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Part modeling; assembly constraints; interference checking; mass properties, Introduction, Study of some Standard Assemblies based on actual machine components. Selection of machine component for assembly drawing. Subassembly Drawing, Full Assembly Drawing, Preparation of Bill of material. Production drawing preparation.</td></tr>
<tr><td colspan="5">UNIT IV: DRAFTING AND STANDARDS</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Engineering drawings; dimensioning; introduction to GD&T; data exchange formats (STEP, IGES), Types and Applications of fits. Dimensional Tolerance, Geometrical Tolerance. Tolerance Grades and Tolerance</td></tr>
</table>

Charts, calculations of dimensional tolerance

UNIT V: CAD APPLICATIONS	**08 Hrs.**

CAD tools like AutoCAD, CATIA, etc. Creating orthographic projections and part models. Dimensioning and tolerance application in CAD. Layers, blocks, hatching and annotations. Importing and exporting technical drawings. Printing and plotting drawings. Reading of blue print drawing, Design for manufacturability; CAD-CAE integration; industrial case studies

TEXT BOOKS:

1. CAD/CAM Principles and Applications – J. Srinivas (Oxford).
2. Computer Graphics – Donald Hearn & M. Pauline Baker.
3. Machine Drawing by N. D. Bhat, Charotar Publications
4. Machine Drawing by P. S. Gill, S. K. Kataria & Sons

REFERENCE BOOKS:

1. CAD/CAM Concepts and Applications – C. R. Alavala.
2. PSG Design Data Book by Kalaikathir Achchagam (PSG College of Technology, Coimbatore)
3. Engineering Drawing Practice for Schools & Colleges (SP-46:1988): Bureau of Indian Standards
4. Design Data For Machine Elements by B. D. Shiwalkar

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th colspan="6">Semester V</th></tr>
<tr><th>Course Code</th><th colspan="3">Course Title</th><th colspan="2">Category</th></tr>
<tr><td>26ES03TH0504-4</td><td colspan="3">Work System Design</td><td colspan="2">PSE</td></tr>
<tr><th colspan="3">Contact Hours per Week</th><th>CA</th><th>FE</th><th>Credits</th></tr>
<tr><th>L</th><th>P</th><th>S</th><th></th><th></th><th></th></tr>
<tr><td>3</td><td>0</td><td>1</td><td>50</td><td>50</td><td>03</td></tr>
<tr><td colspan="6">Prerequisite: Nil</td></tr>
<tr><td colspan="6">Course Objectives:
To develop the ability to design, analyze, and optimize work systems, plant layouts, and production processes using industrial engineering tools, while integrating lean principles, automation, and modern Industry 4.0 practices.</td></tr>
<tr><td colspan="6">Course Outcomes:
Upon successful completion of the course, students will be able to:
1. Apply work study techniques, method study tools, and work measurement methods to improve productivity in manufacturing systems.
2. Analyze different plant layouts, flow patterns, and production systems to determine their suitability for specific industrial scenarios
3. Analyse productivity factors, time standards, and system performance using appropriate industrial engineering metrics and digital tools.
4. Evaluate work system designs and plant layouts by incorporating lean manufacturing principles and automation concepts.
5. Evaluate assembly line balancing, task allocation, and integrated work systems to improve efficiency in modern manufacturing environments.</td></tr>
<tr><td colspan="5">UNIT I: Work System Design and Productivity</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Concept of work systems in manufacturing, productivity, factors affecting productivity, measures to improve productivity. Total time of job, management techniques to reduce work content and ineffective time. work study fundamentals, Digital productivity tracking and smart manufacturing metrics used in Industry 4.0 environments.</td></tr>
<tr><td colspan="5">UNIT II: Method Study and Work Analysis</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Systematic analysis and improvement of work methods using tools such as process charts, flow diagrams, and activity charts, micro-motion study, principles of motion economy, and man-machine interaction analysis. The use of simulation tools, video-based analysis.</td></tr>
<tr><td colspan="5">UNIT III: Work Measurement and Time Standards</td><td>08 Hrs.</td></tr>
</table>

Techniques for measuring work and establishing time standards, including stopwatch time study, work sampling, and predetermined motion time systems (PMTS) such as MTM and MOST. performance rating, allowances, and standard time calculation.	
UNIT IV: Plant Layout	**08 Hrs.**
Plant layout: definition, objectives and types—product, process, fixed position, cellular, layouts with common flow patterns. Production systems: job, batch, line, and continuous production with characteristics, advantages, disadvantages, and selection assumptions. Basic features of modern manufacturing including automation, lean systems, and digital integration.	
UNIT V: Integrated Work Systems, Lean and Automation	**08 Hrs.**
Integration and optimization of complete work systems using modern industrial engineering approaches, Assembly line balancing: cycle time, task sequencing, workstation allocation, efficiency, and simple numerical problems. lean manufacturing, automation, smart factories, IoT-enabled systems, and human-robot collaboration.	
Textbooks 1. Introduction to Work Study by ILO (International Labour Organization) 2. Industrial Engineering and Production Management by Martand Telsang 3. Ralph M. Barnes, *Motion and Time Study:* Design and Measurement of Work, Wiley.	
Reference Books 1. Benjamin W. Niebel & Andris Freivalds, *Methods, Standards, and Work Design*, McGraw-Hill. 2. Maynard's Industrial Engineering Handbook, McGraw-Hill.	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester VI					
Course Code	**Course Title**				**Category**
26ES03TH0606-1	**Drone Technology and UAV Systems**				**PSE**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	P	**S**			
03	01	00	50	50	03

Prerequisite: Basic Robotics, Mechanics

Course Objectives:

1. To introduce fundamentals of UAV systems, classifications, and aerodynamics.
2. To develop understanding of UAV components, sensors, and propulsion systems.
3. To explain flight dynamics, control, and stabilization techniques.
4. To provide knowledge of navigation, path planning, and autonomous operation.
5. To expose students to UAV applications, regulations, and emerging trends.

Course Outcomes: On successful completion of the module students will be able to:

1. Explain UAV types, components, and aerodynamic principles.
2. Analyze UAV propulsion and hardware systems**.**
3. Apply flight dynamics and control strategies for UAV stabilization.
4. Apply navigation and path planning techniques for autonomous UAVs.
5. Evaluate UAV applications, regulations, and system performance.

UNIT I: INTRODUCTION TO UAV SYSTEMS	**08 Hrs.**
Definition and history of UAVs, classification (fixed-wing, rotary-wing, hybrid UAVs). Basic aerodynamics: lift, drag, thrust, and stability. UAV architecture and subsystems overview. Applications in defense, agriculture, logistics, surveillance, and disaster management.	
UNIT II: UAV COMPONENTS AND PROPULSION	**08 Hrs.**
UAV hardware: frame, motors (BLDC), ESC, propellers, batteries. Sensors: IMU, GPS, barometer, magnetometer. Flight controllers and communication modules. Propulsion systems and power requirements. Payload integration and weight considerations.	
UNIT III: FLIGHT DYNAMICS AND CONTROL	**08 Hrs.**
Equations of motion for UAVs (basic). Stability concepts: roll, pitch, yaw control. PID control for UAV stabilization. Attitude estimation using IMU. Introduction to advanced control (LQR, adaptive control). Flight modes and autopilot systems.	
UNIT IV: NAVIGATION AND AUTONOMOUS FLIGHT	**08 Hrs.**
Waypoint navigation, trajectory generation. Path planning algorithms (A*, RRT). Sensor fusion for localization (GPS + IMU). Obstacle detection and avoidance. Introduction to SLAM for UAVs. Autonomous mission planning.	

UNIT V: UAV APPLICATIONS, REGULATIONS AND FUTURE TRENDS	**08 Hrs.**
Applications: precision agriculture, mapping, delivery drones, surveillance. UAV regulations (DGCA guidelines in India), safety and ethical issues. Swarm drones and AI integration. Emerging trends: drone taxis, autonomous fleets, BVLOS operations.	
TEXT BOOKS: 1. Austin, R. – Unmanned Aircraft Systems: UAV Design, Development and Deployment 2. Kimon P. Valavanis & George Vachtsevanos – Handbook of Unmanned Aerial Vehicles 3. Anderson, J. D. (2021). Introduction to Flight (9th ed.). McGraw-Hill Education.	
REFERENCE BOOK: 1. Paul Fahlstrom & Thomas Gleason – Introduction to UAV Systems 2. Small Unmanned Aircraft: Theory and Practice" by Randal W. Beard and Timothy W. McLain.	
MOOC COURSES: 1. Coursera: Aerial Robotics (University of Pennsylvania). 2. PX4 Autopilot Documentation 3. MIT OpenCourseWare UAV lectures	

Ramdeobaba University, Nagpur
Semester V
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B. Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title	Category
26ES03TH0606-2	**Data Exploration and Visualization**	PSE

Contact Hours per Week			CA	ESE	Credits
L	P	S			
03	00	00	50	50	03

Prerequisite: Fundamentals of Data Science, Python Programming, Basic Statistics

Course Objectives:

To develop the ability to explore, interpret, and visually represent diverse datasets for informed decision-making in robotics and AI applications.

Course Outcomes: On successful completion of the module students will be able to:

1. Understand data types, sources, and exploratory analysis principles.
2. Apply statistical summaries and pre-processing techniques for initial data understanding.
3. Use visualization tools to represent trends, patterns, and anomalies.
4. Interpret visual analytics for AI and robotics datasets.
5. Design dashboards and storytelling methods for data-driven insights.

UNIT I: Foundations of Data Exploration — **08 Hrs.**

Introduction to data analytics ecosystem and its role in Robotics and AI. Types of datasets: structured, semi-structured, and unstructured. Data structures such as tables, arrays, and data frames. Data acquisition from sensors, CSV files, databases, and APIs. Data quality dimensions: accuracy, completeness, consistency, and validity. Basics of descriptive statistics including mean, median, mode, variance, and standard deviation. Data distributions, summaries, and introductory data understanding techniques.

UNIT II: Data Preparation for Exploration — **08 Hrs.**

Data pre-processing concepts and importance. Missing value treatment methods. Outlier detection and handling techniques. Data cleaning, duplicate removal, and consistency checks. Data transformation, encoding, and aggregation. Data normalization methods and feature scaling techniques. Sampling methods including random, stratified, and systematic sampling for representative analysis.

UNIT III: Exploratory Data Analysis (EDA) — **08 Hrs.**

Introduction to EDA and its objectives. Univariate, bivariate, and multivariate analysis. Correlation and covariance analysis. Pattern identification and anomaly detection. Trend discovery from datasets. Hypothesis generation through data observation. Dimensional summaries using grouping, pivot tables, and aggregation techniques.

UNIT IV: Visualization Techniques — **08 Hrs.**

Principles of data visualization. Charts including bar, line, histogram, scatter, and boxplot. Comparative and categorical visualization. Time-series visualization methods. Basics of geospatial visualization. Interactive dashboards and reporting. Visualization ethics, bias prevention, and effective communication.

UNIT V: Tools and Applications — **08 Hrs.**

Python libraries: Pandas, Matplotlib, and Seaborn basics. Tableau and Power BI fundamentals. Dashboard creation and reporting basics. Robotics sensor data visualization. AI model output interpretation through graphs and visual summaries. Mini-project on data exploration and dashboard

development.

TEXT BOOKS:

1. Tufte, E. R. (2001). The Visual Display of Quantitative Information (2nd ed.). Graphics Press.
2. McKinney, W. (2022). Python for Data Analysis (3rd ed.). O'Reilly Media.

REFERENCE BOOKS:

1. Healy, K. (2018). Data Visualization: A Practical Introduction. Princeton University Press.
2. Cairo, A. (2016). The Truthful Art: Data, Charts, and Maps for Communication. New Riders.
3. Murray, S. (2017). Interactive Data Visualization for the Web (2nd ed.). O'Reilly Media.
4. Seaborn documentation: https://seaborn.pydata.org
5. Plotly and Dash documentation: https://plotly.com/python/

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th colspan="8">Semester VI</th></tr>
<tr><th>Course Code</th><th colspan="5">Course Title</th><th>Category</th></tr>
<tr><td>26ES03TH0606-3</td><td colspan="5">3-D Printing Technology</td><td>PCC</td></tr>
<tr><th colspan="4">Contact Hours per Week</th><th rowspan="2">CA</th><th rowspan="2">ESE</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>P</th><th>S</th><th>Credits</th></tr>
<tr><td>3</td><td>0</td><td>2</td><td>3</td><td>50</td><td>50</td><td>3</td></tr>
<tr><td colspan="8">Prerequisite: Engineering Graphics, Manufacturing Processes, Basics of Materials Science, CAD (Geometric Modeling), Basic Computer Programming (desirable)</td></tr>
<tr><td colspan="8">Course Objectives: The objective of the course is to prepare the students
1. To develop understanding of additive manufacturing processes, materials, and design principles.
2. To enable students to apply AM tools for prototyping, product development, and industrial applications.</td></tr>
<tr><td colspan="8">Course Outcomes: After completing this course, students will be able to:
1. Explain fundamentals, classifications, and principles of AM processes
2. Apply CAD tools for AM design and file preparation (STL, slicing)
3. Analyze process parameters and material behavior in AM
4. Evaluate AM vs conventional manufacturing for industrial applications
5. Design and fabricate components using AM machines and validate performance</td></tr>
<tr><td colspan="8">Unit 1: Introduction to Additive Manufacturing
Definition, history, evolution, Classification: VAT photopolymerization, powder bed fusion, extrusion Comparison with conventional manufacturing,</td></tr>
<tr><td colspan="8">Unit 2: AM Process Technologies
FDM, SLA, SLS, DMLS, Binder Jetting, Machine components and working principles, Case studies (aerospace, biomedical)</td></tr>
<tr><td colspan="8">Unit 3: Materials in AM
Polymers, metals, ceramics, composites, Material properties and selection, Defects and microstructure</td></tr>
<tr><td colspan="8">Unit 4: Design for Additive Manufacturing
STL conversion, slicing, Topology optimization, Support structures, Software workflow</td></tr>
<tr><td colspan="8">Unit 5: Applications & Future Trends
Industrial applications, Reverse engineering using EinScan 3D Scanner, Sustainability and Industry 4.0 integration, AI in AM</td></tr>
<tr><td colspan="8">TEXT BOOKS:
1. Gibson, Rosen, Stucker – Additive Manufacturing Technologies
2. Ian Gibson – 3D Printing and AM Principles
3. Chua & Leong – Rapid Prototyping
4. Andreas Gebhardt – Understanding AM</td></tr>
</table>

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

REFERENCE BOOKS:
1. Liou – Rapid Prototyping and Engineering Applications
2. Hopkinson – Rapid Manufacturing ASTM Standards on AM

Course Code	Course Title				Category
26ES03TH0606-3	**Facilities Planning and Design**				**PSE**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
03	**00**	**02**	**50**	**50**	**03**

Prerequisite:

Course Objectives:
To equip students with knowledge and techniques for effective utilization of plant space, machines, manpower, material flow, and other resources for improving productivity, Resource Utilization, Layout Optimization and operational efficiency.

Course Outcomes: On successful completion of the module, students will be able to:

CO1: Explain the fundamentals, scope, importance, principles, and objectives of facilities planning and design for manufacturing, service, and modern industrial systems.

CO2: Analyze facility location factors and evaluate process, product, cellular, fixed-position, and hybrid layouts using qualitative and quantitative approaches.

CO3: Apply layout planning and optimization techniques for effective utilization of space, equipment, manpower, material flow, energy, and other organizational resources.

CO4: Select and integrate suitable material handling systems, storage systems, automation-based flow systems, and warehouse practices to improve productivity, safety, and operational efficiency.

CO5: Apply CAD, simulation tools, lean principles, ergonomics, safety, maintenance, sustainability, and Industry 4.0 concepts in facilities planning and design.

UNIT I: Introduction to Facilities Planning	**06 Hrs.**

Meaning, scope, objectives and importance of facilities planning in manufacturing and service industries. Principles and key elements of facilities planning, including plant location, layout, material handling, storage, space utilization, equipment arrangement, safety and ergonomics. Role of facilities planning in improving productivity, cost reduction, smooth workflow and organizational efficiency. Overview of systematic facilities planning, industrial applications, case studies, emerging trends and challenges in facilities planning.

UNIT II: Facility Location Analysis	**06 Hrs.**

Meaning, importance and objectives of facility location analysis. Factors affecting facility location decisions such as raw material availability, market proximity, labour, transportation, land cost, utilities, infrastructure, government policies, environmental and safety requirements. Qualitative and quantitative factors in location selection. Methods of location analysis: factor rating method, load-distance method, centre of gravity method, break-even analysis and transportation model. Selection of location for manufacturing plants, warehouses and service facilities. Case studies and emerging trends in facility location planning.

UNIT III: Layout Planning and Design	**09 Hrs.**

Meaning, objectives and principles of layout planning and design. Types of layouts: process layout, product layout, fixed-position layout, cellular layout and hybrid layout. Factors influencing layout design such as material flow, space utilization, equipment arrangement, manpower movement, safety, flexibility and future expansion. Techniques of layout planning including flow analysis, activity relationship chart, space requirement analysis, block layout and systematic layout planning. Evaluation of layouts based on material handling cost, productivity, workflow efficiency, safety and ergonomics. Use of CAD and simulation tools in layout planning and industrial case studies.

UNIT IV: Material Handling Systems	**09 Hrs.**

Meaning, objectives, importance and principles of material handling systems. Classification of material handling equipment such as conveyors, cranes, hoists, trucks, forklifts, AGVs, robots and automated storage/retrieval systems. Selection of material handling equipment based on material type, quantity, movement distance, flow pattern, safety, cost and flexibility. Analysis of material flow, unit load concept, storage systems, warehouse handling and movement of materials in manufacturing systems. Role of material handling in reducing cost, improving productivity, minimizing delays, ensuring safety and supporting efficient facility layout. Emerging trends such as automation, robotics, smart warehousing and Industry 4.0 in

UNIT V: Facility Design and Maintenance	**09 Hrs.**

Meaning, objectives and importance of facility design and maintenance in manufacturing and service organizations. Factors influencing facility design such as capacity, flexibility, space utilization, workflow, safety, ergonomics, utilities, environmental requirements and future expansion. Principles of effective facility design for improving productivity, operational efficiency and employee safety. Maintenance concepts: preventive maintenance, predictive maintenance, breakdown maintenance and condition-based maintenance. Role of maintenance in reducing downtime, improving equipment reliability and extending facility life. Energy management, waste reduction, green facility design, sustainability and environmental considerations in facility operations. Case studies and modern trends in facility design and maintenance.

TEXT BOOKS:

1. **S. C. Sharma and T. R. Banga**, *Industrial Engineering and Management*, **Second Edition**, Khanna Publishing House, 2025. ISBN: **978-93-55380-09-8**. (Khanna Publishing House)
2. **R. Panneerselvam**, *Production and Operations Management*, **Third Edition**, PHI Learning Pvt. Ltd., New Delhi. ISBN: **978-8120345553**. (PHI Learning)
3. **G. K. Agarwal**, *Plant Layout and Material Handling*, **Second Edition**, Jain Brothers, New Delhi,

2020. ISBN: **978-8186321782**. (Jain Book Depot)

REFERENCE BOOKS:

1. **Tompkins, J. A., White, J. A., Bozer, Y. A., and Tanchoco, J. M. A.**, *Facilities Planning*, Wiley, 2010.
2. **Slack, N., Brandon-Jones, A., and Johnston, R.**, *Operations Management*, Pearson Education Limited, 2016.
3. **Rosenthal, E.**, *Warehouse and Distribution Facility Planning*, CRC Press, 2016.
4. **Chikwendu, D. O.**, *Introduction to Material Handling Systems*, CRC Press, 2015.
5. **Kumar, S.**, *Facility Layout and Location: An Analytical Approach*, CRC Press, 2018.
6. **Hillier, F. S., and Lieberman, G. J.**, *Introduction to Operations Research*, McGraw-Hill Education, 2019.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester VII					
Course Code	**Swarm Robotics**				**Category**
26ES03TH0705-1					**PSE**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	P	**S**			
03	01	1	50	50	03

Prerequisite: Basics of Artificial Intelligence, Fundamentals of Robotics, Basic Probability and Algorithms

Course Objectives:

1. To understand principles of swarm intelligence and collective behavior
2. To study decentralized control and self-organization
3. To analyze bio-inspired optimization algorithms
4. To implement multi-agent coordination strategies
5. To evaluate real-world swarm robotic applications

Course Outcomes: On successful completion of the module students will be able to:

1. Explain principles of swarm intelligence and collective behavior
2. Analyze multi-agent systems and coordination mechanisms
3. Apply swarm intelligence algorithms to optimization problems
4. Evaluate cooperative control strategies in swarm systems
5. Design swarm-based solutions for real-world applications

UNIT I: Introduction to Swarm Intelligence	**08 Hrs.**

Definition and characteristics of swarm intelligence, Natural swarm systems: ants, bees, birds, fish schools, Principles of self-organization: emergence, stigmergy, local interactions, Centralized vs decentralized control, Advantages: scalability, robustness, flexibility, Applications in robotics, optimization, and distributed systems

UNIT II: Multi-Agent Systems	**08 Hrs.**

Fundamentals of multi-agent systems (MAS), Agent architecture: reactive, deliberative, hybrid, Communication models: direct vs indirect (stigmergy), Coordination and cooperation mechanisms, Mathematical modeling of swarm behavior, Graph theory basics in swarm communication networks

UNIT III: Swarm Intelligence Algorithms	**08 Hrs.**

Particle Swarm Optimization (PSO): concept, velocity-position update, Ant Colony Optimization (ACO): pheromone update, path selection, Artificial Bee Colony (ABC) algorithm, Firefly algorithm and other nature-inspired methods, Convergence analysis and parameter tuning, Applications in optimization problems.

UNIT IV: Coordination and Control	**08 Hrs.**

Task allocation strategies, Formation control and flocking behavior (Boids model), Consensus algorithms in distributed systems, Coverage and exploration strategies, Collision avoidance and

obstacle handling, Stability and robustness analysis.

UNIT V: Applications and Case Studies	**08 Hrs.**

Swarm robotics in search-and-rescue missions, Environmental monitoring using multi-robot systems, Applications in agriculture (crop monitoring, spraying), Drone swarms and defense applications, Industrial applications and warehouse automation, Challenges: communication limits, energy constraints, scalability, Future research directions in swarm robotics.

TEXT BOOKS:

1. Swarm Intelligence: From Natural to Artificial Systems by Eric Bonabeau, Marco Dorigo, and Guy Theraulaz.
2. Marco Dorigo & Thomas Stützle – Ant Colony Optimization, The MIT Press Cambridge, Massachusetts
3. Eric Bonabeau – Swarm Intelligence: From Natural to Artificial Systems

REFERENCE BOOK:

1. Andries Engelbrecht – Computational Intelligence
2. Eberhart & Kennedy – Particle Swarm Optimization

MOOC COURSES:

1. NPTEL: Swarm Intelligence & Evolutionary Algorithms
2. Coursera: Multi-Agent Systems
3. MIT OpenCourseWare: Distributed AI

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th colspan="6">Semester VII</th></tr>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>26ES03TH0705-2</td><td colspan="4">Data Engineering</td><td>PSE</td></tr>
<tr><th colspan="3">Contact Hours per Week</th><th>CA</th><th>ESE</th><th>Credits</th></tr>
<tr><th>L</th><th>P</th><th>S</th><th></th><th></th><th></th></tr>
<tr><td>03</td><td>00</td><td>00</td><td>50</td><td>50</td><td>03</td></tr>
<tr><td colspan="6">Prerequisite: Databases (SQL/NoSQL), Python Programming, Basic Cloud Computing</td></tr>
<tr><td colspan="6">Course Objectives:
To build competencies in scalable data pipeline creation, distributed processing, and infrastructure for AI-ready systems.</td></tr>
<tr><td colspan="6">Course Outcomes: On successful completion of the module students will be able to:
1. Understand large-scale data architectures.
2. Build ETL and ELT workflows.
3. Implement distributed storage solutions.
4. Use big data frameworks for processing.
5. Engineer real-time data systems for robotics and AI ecosystems.</td></tr>
<tr><td colspan="5">UNIT I: Foundations of Data Engineering</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Introduction to data engineering and its role in Robotics and AI systems. Data lifecycle engineering including data generation, ingestion, storage, processing, analysis, and archival. Fundamentals of pipeline architecture and components of modern data pipelines. Batch processing and streaming systems with comparative analysis. Data integration concepts for combining multiple data sources. Workflow concepts, automation basics, and reliability in engineering data movement.</td></tr>
<tr><td colspan="5">UNIT II: Modern Data Storage</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Introduction to modern data storage architectures. Data warehouses and their role in structured analytics. Data lakes for large-scale raw data storage. Lakehouse concepts integrating warehouse and lake capabilities. NoSQL systems including key-value, document, and columnar databases. Distributed file systems and scalable storage models for large data environments. Storage selection for AI and robotics applications.</td></tr>
<tr><td colspan="5">UNIT III: ETL/ELT Systems</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Concepts of Extract, Transform, Load (ETL) and Extract, Load, Transform (ELT). Data extraction methods from sensors, APIs, logs, and databases. Transformation pipelines for cleaning, enrichment, and aggregation. Workflow scheduling using automation tools. Data orchestration principles for pipeline coordination. Pipeline monitoring, validation, logging, and fault handling for reliable data engineering systems.</td></tr>
</table>

UNIT IV: Big Data Processing	**08 Hrs.**
Introduction to big data characteristics and processing requirements. Hadoop ecosystem fundamentals including HDFS and MapReduce concepts. Apache Spark basics for distributed data processing. Stream processing fundamentals for real-time applications. Kafka basics for distributed messaging and event streaming. Overview of cloud data platforms and scalable infrastructure for large-scale engineering.	
UNIT V: Robotics and AI Data Pipelines	**08 Hrs.**
Engineering pipelines for robotics sensor streams and IoT data. Edge-to-cloud architecture for real-time intelligent systems. Autonomous system data flow and decision pipeline fundamentals. Introduction to MLOps and DataOps concepts for model and data lifecycle management. Design considerations for scalable AI pipelines. Capstone pipeline design integrating acquisition, storage, processing, and deployment for Robotics and AI applications.	

TEXT BOOKS:

1. Reis, J., & Housley, M. (2022). Fundamentals of Data Engineering. O'Reilly Media.
2. Chambers, B., & Zaharia, M. (2018). Spark: The Definitive Guide. O'Reilly Media.

REFERENCE BOOKS:

1. Kleppmann, M. (2017). Designing Data-Intensive Applications. O'Reilly Media.
2. Gorelik, A. (2019). The Enterprise Big Data Lake. O'Reilly Media.
3. Apache Airflow Documentation: https://airflow.apache.org/docs/

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><td colspan="7">Semester VII</td></tr>
<tr><td>Course Code</td><td colspan="4">Course Title</td><td colspan="2">Category</td></tr>
<tr><td>26ES03TH0705-3</td><td colspan="4">Computer Integrated Manufacturing System</td><td colspan="2">PSE</td></tr>
<tr><td colspan="3">Contact Hours per Week</td><td>CA</td><td>ESE</td><td colspan="2">Credits</td></tr>
<tr><td>L</td><td colspan="2">P</td><td>Total</td><td></td><td></td><td></td></tr>
<tr><td>03</td><td colspan="2">00</td><td>03</td><td>50</td><td>50</td><td colspan="2">03</td></tr>
<tr><td colspan="7">Prerequisite: Manufacturing and production Engineering, Programming</td></tr>
<tr><td colspan="7">Course Objectives:
1. To provide students with the fundamental concepts of Computer Integrated Manufacturing, automation technologies, CNC/CAM systems and manufacturing integration.
2. To develop the ability to analyse automated manufacturing systems and modern manufacturing tools and Industry 4.0 concepts for improving production efficiency.</td></tr>
<tr><td colspan="7">Course Outcomes: On successful completion of the module students will be able to:
1. Explain the architecture and components of Computer Integrated Manufacturing systems. automation strategies
2. Analyze automated flow line systems and perform line balancing calculations.
3. Apply CNC programming and explain CAD–CAM integration in manufacturing.
4. Demonstrate understanding of PLC, robotics, and their role in manufacturing automation.
5. Interpret production data systems and modern Industry 4.0 concepts in manufacturing.</td></tr>
<tr><td colspan="6">UNIT I: Introduction</td><td>08 Hrs.</td></tr>
<tr><td colspan="7">Evolution of manufacturing systems, Concept, scope, and objectives of CIM, Components and architecture of CIM, Types of production systems (job, batch, mass, flexible), Automation strategies and levels of automation, Transfer mechanisms, Production line terminology and analysis</td></tr>
<tr><td colspan="6">UNIT II: Analysis of Automated flow lines</td><td>08 Hrs.</td></tr>
<tr><td colspan="7">Analysis of Automated flow lines- Analysis of transfer lines without storage, Storage buffer effectiveness, automated flow lines with storage buffers, Line Balancing: methods of line balancing and algorithms</td></tr>
<tr><td colspan="6">UNIT III: CNC & CAM Integration</td><td>08 Hrs.</td></tr>
<tr><td colspan="7">Fundamentals of CNC machines and control systems, Machine control unit and NC components, Coordinate systems, interpolation methods, Basics of part programming (G-code, M-code), Introduction to CAM and toolpath generation, tool motion, NC part programming features, applications of NC, CAD–CAM integration workflow.</td></tr>
<tr><td colspan="6">UNIT IV: Industrial Automation</td><td>08 Hrs.</td></tr>
<tr><td colspan="7">Basics of industrial robotics (configuration, applications), Robot integration in manufacturing lines, PLC–Robot coordination (conceptual), Introduction to Flexible Manufacturing Systems (FMS), Automated material handling, AGVS, AS/RS</td></tr>
<tr><td colspan="6">UNIT V: Production Planning, Data Systems & Industry 4.0</td><td>08 Hrs.</td></tr>
</table>

Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, Production Planning and Control (PPC), MRP and ERP overview, Shop-floor control, Introduction to CAPP and types, Quality Function Deployment, Industry 4.0: IoT, smart manufacturing, digital twin

TEXT BOOKS:

1. Automation, production System & CIMS: M. P. Groover, Prentice Hall of India, New Delhi
2. CNC Machines: M. Adithan& B. S. Pabla, New Age International Publications New Delhi
3. CAD/CAM: Computer-Aided Design and Manufacturing, Prentice Hall of India.
4. CAD/CAM: M. Groover& E. Zimmers, Pearson Education, Delhi

REFERENCE BOOKS:

1. Industrial Engg. & Production Management : Martand Telsang, S. Chand Publications, Delhi
2. Computer Control of Manufacturing Systems: Yoram Koren, Mcgraw Hill, Delhi
3. Computer Integrated Manufacturing, PHI Learning. Industrial Robotics: M. P. Groover, Roger N. Nagel, Mc Grow-Hill, New Delhi
4. Flexible Manufacturing Systems, New Age International.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester VII					
Course Code	**Course Title**				**Category**
26ES03TH0705-4	**Operation Research**				**PSE**
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**Total**			
03	00	**03**	50	50	03

Prerequisite:

Course Objectives:

Course Outcomes: On successful completion of the module students will be able to:
1. Convert given situation to mathematical form and determine optimal settings. 2. 3. 4. 5. 6.
2. Apply LPP tool to determine optimal settings in various applications.
3. Use sequential optimization approach to find optimal setting in many real-life situations.
4. Manage projects for minimum total cost and smooth level of resources.
5. Make decisions related to age of replacement of equipment

UNIT I: Introduction	**08 Hrs.**
Definition Characteristics and limitations of OR, linear programming, solutions of LPP by graphical method and simplex method, Duality theory, Sensitivity analysis, use of software to solve LPP.	
UNIT II:	**08 Hrs.**
Assignment Model, Travelling Salesman Problem by branch and bound method, Transshipment model, Transportation Model	
UNIT III:	**08 Hrs.**
Dynamic programming structure and characteristics of Dynamic programming application of Dynamic programming to resource allocation	
UNIT IV: Project Management	**08 Hrs.**
Drawing of Network, CPM & PERT, probability of completion of project, cost analysis, Allocation and updating of Networks, Project Management Software.	
UNIT V: Replacement Models	**08 Hrs.**
Concept of equivalence, Interest Rate, Present worth, economic evaluations of Alternatives, Group replacement models. Use of spreadsheet tool to solve replacement problem	

TEXT BOOKS:

1. Heera & Gupta, Operation Research: S Chand Publications

2. J K Sharma, Operation Research: McMillian Publications

3. Panneer Selvam Operations Research: TMH Publications

REFERENCE BOOKS:

1. Hamdy Taha, Operation Research, Prentice Hall
2. Liberman, Operation Research, McGraw Hill Publications
3. S D Sharma Operation Research, Kedarnath Ramnath & Co.
4. Paul A. Jensen and Jonathan F. Bard, Operations Research: Models and Methods John Wiley and Sons.

Semester VII

Course Code	Course Title				Category
26ES03TH0706-1	**Cognitive Robotics**				**PSE**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	P	**S**			
3	0	1	50	50	3

Prerequisite: Introductory Robotics, Fundamentals of Artificial Intelligence

Course Objectives:

1. To introduce the principles and architectures of cognitive robotics.
2. To develop understanding of perception, attention, and learning in intelligent robots.
3. To explain reasoning, planning, and decision-making mechanisms.
4. To provide insights into human-robot interaction and social cognition.

Course Outcomes: On successful completion of the module students will be able to:

1. Explain cognitive architectures and knowledge representation methods in robotics.
2. Analyze perception, attention, and multimodal sensing techniques in cognitive systems.
3. Apply learning mechanisms such as imitation and reinforcement learning in robotic systems.
4. Analyze reasoning and planning methods for decision-making under uncertainty.
5. Evaluate human-robot interaction and social cognition strategies in real-world scenarios.

UNIT I: INTRODUCTION TO COGNITIVE ROBOTICS	**08 Hrs.**

Definition and scope of cognitive robotics, distinction between programmed automation, AI, and cognitive systems. Embodiment hypothesis: role of physical interaction in intelligence. Overview of cognitive architectures: SOAR, ACT-R, and Subsumption architecture. Symbolic vs connectionist approaches, knowledge representation using semantic networks and ontologies.

UNIT II: COGNITIVE PERCEPTION AND ATTENTION	**08 Hrs.**
Active perception and goal-driven sensing. Selective attention mechanisms. Object affordances and action-based understanding. Multimodal perception integrating vision, audio, and haptics. Spatial cognition: cognitive maps, landmark recognition, and environment representation.	
UNIT III: LEARNING AND DEVELOPMENTAL ROBOTICS	**08 Hrs.**
Developmental learning concepts: exploration and motor babbling. Imitation learning and programming by demonstration. Memory systems: working, episodic, and procedural memory. Reinforcement learning for decision-making in dynamic environments.	
UNIT IV: REASONING, PLANNING, AND ANTICIPATION	**08 Hrs.**
Decision making under uncertainty using Bayesian and fuzzy logic. Predictive modeling and anticipation of future states. Planning methods: STRIPS, hierarchical task networks (HTN). Introduction to Theory of Mind (ToM) for modeling intentions of agents.	
UNIT V: SOCIAL COGNITION AND HUMAN-ROBOT INTERACTION	**08 Hrs.**
Social robotics: emotion recognition, gesture and speech understanding. Human-robot collaboration and joint action. Natural language grounding in robotics. Ethical considerations, safety standards, and autonomous decision-making in human environments.	
TEXT BOOKS: 1. Robin R. Murphy – *Introduction to AI Robotics* 2. Stuart Russell & Peter Norvig – *Artificial Intelligence: A Modern Approach*	
REFERENCE BOOKS: 1. Margaret A. Boden – *Mind as Machine: A History of Cognitive Science* 2. Thrun, Burgard, Fox – *Probabilistic Robotics*	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Semester VII					
Course Code	**Course Title**				**Category**
26ES03TH0706-2	**Data Privacy**				PSE
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**S**			
03	00	00	50	50	03

Prerequisite: Probability and Statistics, Introductory Machine Learning, Database Management

Course Objectives:
To enable secure, ethical, and regulation-compliant handling of data across robotics, AI, and digital ecosystems.

Course Outcomes: On successful completion of the module students will be able to:

1. Understand privacy principles and security foundations.
2. Apply data protection mechanisms and encryption.
3. Evaluate privacy risks in AI and robotics systems.
4. Implement governance and compliance frameworks.
5. Design secure data environments for autonomous technologies.

UNIT I: Privacy Fundamentals	**08 Hrs.**

Introduction to data privacy and its significance in digital, AI, and robotics ecosystems. Core concepts of privacy, confidentiality, and data ownership. Personal data vs sensitive data classification. Fundamental privacy principles including consent, transparency, purpose limitation, and data minimization. Understanding privacy risks in data collection and processing.

UNIT II: Security Mechanisms	**08 Hrs.**

Foundations of cybersecurity and information security principles. Cryptography basics including symmetric and asymmetric encryption. Encryption models for data at rest and data in transit. Authentication methods such as passwords, biometrics, and multi-factor authentication. Access control models including role-based and permission-based systems.

UNIT III: Privacy-Preserving Technologies	**08 Hrs.**

Techniques for protecting user identity and sensitive information. Anonymization and de-identification methods. Pseudonymization for privacy enhancement. Differential privacy concepts for secure analytics. Secure data sharing mechanisms and controlled access frameworks. Introduction to privacy-preserving

machine learning. Federated learning basics for decentralized AI training. Applications of privacy technologies in AI systems, IoT networks, and robotics data environments.

UNIT IV: Legal and Governance Frameworks	**08 Hrs.**

Introduction to global and national privacy regulations. GDPR concepts including rights, obligations, and compliance principles. Overview of Indian data protection regulations and digital governance. Compliance requirements for organizations handling personal data. Governance models for privacy and cybersecurity management.

UNIT V: Secure AI and Robotics Systems	**08 Hrs.**

Cybersecurity challenges in robotics and autonomous systems. Privacy issues in IoT-enabled devices and sensor networks. Adversarial threats to AI models and intelligent machines. Secure deployment strategies for AI and robotic systems. Safety, resilience, and trustworthiness in real-world deployments. Case studies on privacy breaches and security incidents.

TEXT BOOKS:

1. Dwork, C., & Roth, A. (2014). The Algorithmic Foundations of Differential Privacy. Foundations and Trends in Theoretical Computer Science, 9(3-4), 211-407.
2. Aggarwal, C. C., & Yu, P. S. (Eds.). (2008). Privacy-Preserving Data Mining: Models and Algorithms. Springer.

REFERENCE BOOKS:

1. Abadi, M., et al. (2016). Deep learning with differential privacy. ACM CCS 2016.
2. McMahan, H. B., et al. (2017). Communication-efficient learning of deep networks from decentralized data. AISTATS.
3. EU GDPR Full Text: https://gdpr-info.eu/
4. OpenDP Library: https://opendp.org/
5. Opacus (PyTorch DP): https://opacus.ai/

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th colspan="6">Semester VII</th></tr>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>26ES03TH0706-3</td><td colspan="4">Sustainability and Green Manufacturing</td><td>PSE</td></tr>
<tr><th colspan="3">Contact Hours per Week</th><th rowspan="2">CA</th><th rowspan="2">ESE</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>P</th><th>S</th></tr>
<tr><td>3</td><td>0</td><td>1</td><td>50</td><td>50</td><td>03</td></tr>
<tr><td colspan="6">Prerequisite: Basic knowledge of Manufacturing Processes, Materials Science, and Environmental Studies.</td></tr>
<tr><td colspan="6">Course Objectives:
After completing this course, students will be able to:
1. Study the concepts, principles, and approaches of sustainable and green manufacturing.
2. Understand modern techniques and strategies used to improve sustainability and productivity in manufacturing processes.</td></tr>
<tr><td colspan="6">Course Outcomes:
After successful completion of the course, students will be able to:
1. Understand concept of green manufacturing and approaches for sustainable Manufacturing.
2. Understand green manufacturing techniques and Process performance with Industrial case studies.
3. Understand application of productivity measures and techniques for machinability improvement.
4. Understand modern approaches for Sustainable Manufacturing
5. Understand and implement strategies for waste reduction, energy efficiency, and sustainable resource management in manufacturing systems</td></tr>
<tr><td colspan="5">UNIT I: Introduction to sustainable manufacturing.</td><td>8 Hours</td></tr>
<tr><td colspan="6">Introduction of green factory, Sustainability and its relevance. Metrics for green manufacturing. Modern approaches for Sustainable Manufacturing, Toxic substances in industry and need of Renewable sources.</td></tr>
<tr><td colspan="5">UNIT II: importance of green manufacturing</td><td>8 Hours</td></tr>
<tr><td colspan="6">Difficulties in machining. Importance of cutting fluids, Health hazard and environmental issues using coolants. Coolant selection criteria. Motivations behind the use of green machining. Study of Green manufacturing techniques and Process performance with Industrial and research based case studies.</td></tr>
<tr><td colspan="5">UNIT III: Systems concept for productivity improvement</td><td>8 Hours</td></tr>
<tr><td colspan="6">Application of productivity measures. Typical measures of affecting productivity. Machinability: Techniques for Machinability improvement. Various Instruments used for Green Machining.</td></tr>
<tr><td colspan="5">UNIT IV: Modern approaches for Sustainable Manufacturing</td><td>8 Hours</td></tr>
</table>

Efficiency of Manufacturing Processes. Energy Efficiency characterization of Manufacturing Processes. Energy Efficiency Practices in Manufacturing .	
Unit V: Green Manufacturing Techniques	**8 Hours**
Dry Machining, Near-Dry Machining (Minimum Quantity Lubrication - MQL), Edible Oil-Based Cutting Fluids, Cryogenic Machining – principles, working, advantages, limitations, and comparison with conventional machining.	
TEXT BOOKS: 1. Green Manufacturing: Fundamentals and Applications by David A. Dornfeld, Springer US publisher 2013. 2. Green Manufacturing Process and System by Davim J. Paulo, Springer Verlag Berlin Heidelberg publication 2013	
REFERENCE BOOKS: 1. Efficiency of Manufacturing Process- Energy and Ecological Perspectives by Li Wen. Springer International Publisher – 2015	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

<table>
<tr><th colspan="6">Semester VII</th></tr>
<tr><th>Course Code</th><th colspan="4">Course Title</th><th>Category</th></tr>
<tr><td>24ES03TH0504-4</td><td colspan="4">Human Factors Engineering</td><td>PCC</td></tr>
<tr><th colspan="3">Contact Hours per Week</th><th>CA</th><th>FE</th><th>Credits</th></tr>
<tr><th>L</th><th>T</th><th>D/P</th><th></th><th></th><th></th></tr>
<tr><td>03</td><td>0</td><td>00</td><td>50</td><td>50</td><td>03</td></tr>
<tr><td colspan="6">Prerequisite: Nil</td></tr>
<tr><td colspan="6">Course Objectives:
To enable students to understand and apply human factors and ergonomic principles for designing safe, efficient, and productive work systems by integrating human capabilities with workplace, environmental, cognitive, physiological, and biomechanical considerations.</td></tr>
<tr><td colspan="6">Course Outcomes:
Upon successful completion of the course, students will be able to:
1. Apply principles of ergonomics and human factors to improve productivity and human–machine system design.
2. Analyse anthropometric, cognitive, physiological, and biomechanical data for effective workplace design.
3. Examine human information processing, sensory systems, and environmental factors affecting human performance.
4. Evaluate workstation layouts, ergonomic conditions, and work environments for safety, efficiency, and comfort.
5. Design human-centered work systems integrating ergonomics, biomechanics, and environmental considerations for improved system performance.</td></tr>
<tr><td colspan="5">UNIT I: Fundamentals of Human Factors Engineering</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Relationship between ergonomics and productivity improvement. Human–machine system concepts and interaction principles. Fundamentals of ergonomic design. Process of ergonomics application in system design and optimization. Principles of Ergonomics, Process and application of Ergonomics.</td></tr>
<tr><td colspan="5">Unit – II: Anthropometry and Workplace Design:</td><td>08 Hrs.</td></tr>
<tr><td colspan="6">Engineering anthropometry including structural and functional body dimensions. Collection and application of anthropometric data in design. Percentile concepts and population variability in workplace design. Design of workstations for seated and standing tasks. Seat design principles focusing on posture, adjustability, and comfort. Layout design for efficient human performance.</td></tr>
</table>

Unit – III: Cognitive Ergonomics	**8 Hrs.**
Human information processing model including perception, cognition, and response. Role of memory in task execution and learning. Problem solving and troubleshooting behavior in work systems. Decision-making processes and mental workload. Meta-cognition and cognitive effort in complex tasks. Application of cognitive principles in system and interface design	
Unit – IV: Work Physiology and Biomechanics of Work	**8 Hrs.**
Metabolism and energy expenditure during physical activity. Muscle structure and biomechanics of human movement. Heat regulation and thermal stress in work environments. Physical work capacity and fatigue analysis. Musculoskeletal system and biomechanical modeling of human effort. Low back pain, cumulative trauma disorders, and NIOSH guidelines for manual handling.	
Unit – V: Physical Ergonomics and Environmental Factors	**8 Hrs.**
Visual, auditory, tactile, and vestibular sensory systems and their role in human performance. Effects of noise, illumination, and heat on work efficiency and safety. Principles of environmental ergonomics in workplace design. Design of displays and controls for effective human interaction. Optimization of physical work environment for comfort, safety, and productivity.	
Textbooks 1.An Introduction to Human Factors Engineering- Christopher D. Wickens, John D. Lee	
Reference Books 1. Human factors Engineering & Design - Mark S. Sanders. Ernest J. Me McCormick: McGraw Hill International Edition 30th September 1992 7th Edition 2. Ergonomics: Man, in his working Environment-Murrell, Chapman and Hall London1980 1stEdition	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

MDM track-I

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code: 26ES04TH0307-1			Course: Defense Platforms (MDM)
L: 3	T: 0	P: 0	Total Credits: 3
Semester: III			Total Marks: 100

Course Objectives:

1. To introduce students to the structural, functional, and technological aspects of land, naval, and aerial defense platforms.
2. To develop awareness about emerging technologies, indigenous capabilities, and strategic applications in defense systems

Course Outcomes:

1. Identify and classify various defense platforms used in land, sea, and air operations.
2. Explain the basic design principles behind mobility, protection, and firepower in defense vehicles.
3. Demonstrate an understanding of the structure and functions of naval and aerial defense systems.
4. Analyze the role of emerging technologies such as AI, robotics, and unmanned systems in modern defense applications.
5. Evaluate India's indigenous defense capabilities and compare them with global defense technologies.

Syllabus

Unit 1: Introduction to Defense Systems and Platforms	**08 Hrs**

Overview of national defense and security framework, Classification of defense platforms: Land, Air, Naval, Cyber, and Space, Basic technology: weapon systems, support systems, communication and control, Role of mechanical engineers in defense.

Unit 2: Land-Based Platforms	**08 Hrs**

Tracked vehicles: Tanks, Armoured Recovery Vehicle's, Light Tanks, Infantry Combat Vehicles (ICVs), Armoured Personnel Carriers (APCs), Artillery systems: Towed, Self-Propelled Gun, Advanced Towed Artillery Gun System (ATAGS), Design principles: mobility, armour, firepower, Logistics and maintenance systems

Unit 3: Naval Platforms	**08 Hrs**

Design, structure and classification of vessels, Warships: Destroyers, Frigates, Corvettes, Submarines, Propulsion systems: Diesel-electric, nuclear, Weaponry and stealth in naval platforms, Vehicle robotics and underwater drones.

Unit 4: Aerial Platforms	**08 Hrs**

Fighter aircraft types (Tejas, Sukhoi-30 MKI), UAV/drones: Nishant, Rustom, Heron, Helicopters: LCH, ALH Dhruv, Apache, Aerodynamics, propulsion, stealth and avionics, Future aerial combat systems

Unit 5: Emerging Technologies in Defense	**08 Hrs**
Network centric warfare and systems, Artificial Intelligence and decision making, Directed Energy Weapons (DEW)/EMRG (railgun/coilgun etc), Unmanned systems: hypersonics, swarm drones, directed-energy weapons, indigenous technology development	
Books: 1. *Understanding Modern Warfare* – David Jordan et al. 2. *Introduction to Defense Acquisition Management* – Defense Acquisition University 3. *Weapons: An International Encyclopedia* – Diagram Group 4. *Military Vehicle Technology* – David McLellan 5. *Jane's Armour and Artillery* – Jane's Information Group	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code: 26ES04TH0407-1			Course: Warfare Systems (MDM)
L: 3	T: 0	P: 0	Total Credits: 3
Semester: IV			Total Marks: 100

Course Objectives:

1. To provide insights into historical and modern warfare systems and their technological evolution.
2. To understand the structure, components, and working principles of various warfare systems.
3. To explore mechanical engineering contributions in designing and maintaining warfare technologies.

Course Outcomes:

1. Define and classify different types of warfare and identify their historical evolution.
2. Analyze the mechanical engineering aspects of conventional weapon systems including tanks, firearms, and artillery.
3. Explain the design and functioning of naval and submarine warfare systems including propulsion and stealth.
4. Evaluate air and space warfare capabilities including aircraft design, missile systems, and satellite surveillance.
5. Assess modern cyber and electronic warfare technologies and their impact on mechanical system vulnerabilities.

Syllabus

Unit 1: Fundamentals of Warfare Systems	**08 Hrs**
Definition and evolution of warfare, Classifications: Conventional, Asymmetric, Cyber, Electronic, Nuclear, Mechanics and dynamics of military engagements, Mechanical engineering relevance in warfare design	
Unit 2: Conventional /Land Warfare Systems	**08 Hrs**
Ballistics and projectile dynamics, Firearms, artillery, and their mechanical subsystems, Tanks and armored systems – mobility and firing mechanisms, Personal protective equipment and soldier systems.	
Unit 3: Naval and Submarine Warfare	**08 Hrs**
Structure and propulsion of naval ships and submarines, Torpedoes, anti-ship missiles, and sonar systems, Stealth technologies and undersea warfare strategies, Role of materials and mechanics in naval platforms	
Unit 4: Air and Space Warfare	**08 Hrs**
Combat aircraft and missile systems – design and aerodynamics, Air defense systems – RADAR, AWACS, SAMs, Space-based warfare capabilities – satellites and surveillance, Anti-satellite weapons and hypersonic threats	
Unit 5: Cyber and Electronic Warfare	**08 Hrs**

Electronic warfare systems – jammers, decoys, ECM and ECCM, Cyber-attacks and defenses – mechanical system vulnerabilities, Role of AI, IoT and robotics in future warfare, Hybrid warfare and information warfare trends

Textbook

1. *Introduction to Modern Warfare Systems* – DRDO Publication
2. *Warfare and Military Technology* – Martin van Creveld

Reference Books

1. *Art of War* – Sun Tzu
2. *Modern Weapons and Warfare* – Chris Bishop
3. *Future Warfare* – Col. John Antal
4. *Understanding Cyber Warfare* – Christopher Whyte
5. DRDO, HAL, and Ministry of Defence technical papers and publications

Online Resources

1. https://drdo.gov.in – DRDO Official Site
2. https://mod.gov.in – Ministry of Defence, India
3. https://nptel.ac.in – NPTEL Modules
4. YouTube Channels: Indian Army, Indian Navy, DRDO, HAL
5. Coursera/edX
6. AI in Defense, Cybersecurity Fundamentals, Military Technology Courses

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code: 26ES04TH0507-1			Course: Weapon Systems (MDM)
L: 3	T: 0	P: 0	Total Credits: 3
Semester: V			Total Marks: 100

Course Objectives:

1. Understand the fundamental principles, ballistics, and operational mechanics of modern weapon systems.
2. Study weapon systems in the context of the three defence services — Army, Navy, and Air Force.
3. Analyse India's defence production policy framework and the industrial ecosystem supporting weapon manufacturing.
4. Examine manufacturing technologies, quality assurance, and supply chain structures in weapon production.
5. Evaluate indigenous weapon manufacturing programmes as instruments of self-reliance under Aatmanirbhar Bharat.

Course Outcomes:

1. Classify and describe the types of weapon systems deployed across Army, Navy and Air Force platforms.
2. Explain the principles of internal, external and terminal ballistics and their engineering implications.
3. Analyse service-specific weapon systems — their design, integration and operational deployment.
4. Evaluate India's defence production policy framework, industrial ecosystem and technology mechanisms.
5. Assess indigenous weapon manufacturing programmes with respect to technology, production scale and self-reliance.

Syllabus

Unit 1: Introduction to Weapon Systems	**08 Hrs**

Definition and classification of weapon systems, Evolution of weapon systems from ancient to modern era, Components: launcher, projectile, guidance, fire control, Precision-guided munitions (PGMs), loitering munitions, Role of mechanical engineering in weapon design.

Unit 2: Missile and Rocket Systems	**08 Hrs**

Basic structure and classification of missiles and rockets, Propulsion systems – solid, liquid, hybrid, Aerodynamics and heat shielding, Guidance and control mechanisms, Launch platforms – mobile, static, naval and aerial-based.

Unit 3: Defence Production Policy & Industrial Ecosystem	**08 Hrs**

Evolution of India's defence production policy, Categories of defence procurement, Make I & II, Defence Industrial Corridors, Defence Public Sector Undertakings (DPSUs), Private sector integration, offset policy, ToT (Transfer of Technology) mechanisms and FDI limits in defence manufacturing.

Unit 4: Weapon Manufacturing Technologies	**08 Hrs**

Weapon-grade materials, Precision machining, Forging and casting of weapon components, Heat treatment

and surface hardening, Additive manufacturing (3D printing), Ammunition manufacturing, Non-destructive testing (NDT), Quality assurance framework, Supply chain management, vendor development, indigenisation of critical sub-systems technologies.

Unit 5: Indigenous Weapon Manufacturing Programmes in India	**08 Hrs**

Dhanush 155mm Howitzer, AK-203 Assault Rifle programme, Pinaka Multi-Barrel Rocket System, AKASH Surface-to-Air Missile System, Arjun Main Battle Tank Mk1A, Light Combat Aircraft Tejas and its gun/weapon delivery system: HAL's production scaling, Mk1A order.

Textbook

1. *Principles of Guided Missile Design* – Dr. M. N. Sinha
2. *Weapon Systems and Ballistics* – R.K. Arora

Reference Books

1. *Modern Weapons and Warfare* – Chris Bishop
2. *Fundamentals of Naval Weapons Systems* – CDR Craig M. Payne (US Navy)
3. *Missile Guidance and Control Systems* – George M. Siouris
4. *Indian Defence Technology Series* – DRDO Publications
5. *Military Ballistics: A Basic Manual* – Malcolm J. D. Powell

Online Resources

1. https://drdo.gov.in – DRDO Official Site
2. https://nptel.ac.in – NPTEL Defense Modules
3. YouTube Channels: DRDO, Bharat Forge, Indian Army Tech, MBDA Missiles
4. Coursera/edX: Missiles and Rockets, Fundamentals of Ballistics, Weapon Design
5. YouTube Channels: Indian Army, Indian Navy, DRDO, HAL
6. Coursera/edX: AI in Defense, Cybersecurity Fundamentals, Military Technology Courses

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code: 26ES04TH0507-1			Course: Self-Defense & Protection system (MDM)
L: 3	T: 0	P: 0	Total Credits: 3
Semester: VI			Total Marks: 100

Course Objectives:

1. To introduce students to the fundamentals and technologies behind personal, vehicular, and infrastructure protection systems.
2. To study the application of mechanical and material engineering in designing armor, shelters, and anti-threat mechanisms.
3. To develop an understanding of modern self-defense technologies and threat mitigation strategies in civil and military domains.

Course Outcomes:

1. Classify and explain different types of self-defense and protection systems used by individuals and defense forces.
2. Understand the design and materials used in bulletproof vests, helmets, and riot gear.
3. Analyze vehicle protection technologies including mine-resistant and ambush-protected (MRAP) designs.
4. Evaluate technologies used in anti-intrusion, perimeter security, and blast mitigation.
5. Assess new-age protection technologies such as exoskeletons, active armor, and AI-based threat response.

Syllabus

Unit 1: Introduction to Self-Defense & Protection System	**08 Hrs**

Threat landscape: Civilian and military, Classification: Personal, vehicle, infrastructure protection, Principles of threat assessment and risk analysis, Historical evolution of armor and protective technologies

Unit 2: Personal Protective Equipment (PPE)	**08 Hrs**

Ballistic vests, helmets, shields – materials and manufacturing, Stab and blast resistant clothing, Riot gear and tactical suits, Standards: NIJ, STANAG, IS codes.

Unit 3: Vehicle Protection Systems	**08 Hrs**

Armoring of military and VIP vehicles, Design of MRAPs, blast seats, and underbody protection, Transparent armor: bulletproof glass and visors, Add-on and reactive armor systems.

Unit 4: Infrastructure and Perimeter Protection	**08 Hrs**

Blast-proof bunkers and shelters – structural design, Perimeter security: fences, intrusion sensors, drones, Access control, surveillance systems, and automated countermeasures.

Unit 5: Advanced & Smart Protection Technologies	**08 Hrs**
Exoskeletons and wearable robotics, Active protection systems (APS): Trophy, Iron Fist, Drone detection and counter-UAV systems, AI-based threat detection and emergency response systems.	

Textbook

1. *Personal Protective Equipment: Design, Material and Technologies* – Joseph R. Davis
2. *Armor and Protection Systems* – R.K. Arora

Reference Books

1. *Modern Ballistic Armor* – L. J. Arnold
2. *Protective Relaying and Infrastructure Defense* – J. Lewis Blackburn
3. *Blast Protection of Civil Infrastructures and Vehicles* – A. G. Malvar
4. DRDO Publications and DRTC Lecture Notes on Protective Systems
5. IS/NIJ/STANAG specifications and defense procurement guidelines

Online Resources

1. https://drdo.gov.in – DRDO Official Site
2. https://bis.gov.in – Bureau of Indian Standards
3. NPTEL modules on material science, structural protection, smart systems
4. YouTube: DRDO labs, Military Tech, PPE testing videos
5. Coursera/edX: Courses on smart wearables, armor design, structural protection

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

MDM Track-II

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code		Course Title				Category
26ES03TH0307-2		Fundamentals of Robotics				MDM
Contact Hours per Week				CA	ESE	Credits
L		P	Total			
03		00	**03**	50	50	03

Prerequisite:

Course Objectives:

1. To introduce the fundamental concepts of robot anatomy, configurations, and workspace.
2. To familiarize students with the working principles of various sensors and actuators used in robotics.
3. To provide an overview of robot control, programming methods, and their role in modern industry.

Course Outcomes: On successful completion of the module students will be able to:

1. Explain basic concepts, structure, robot configurations, and classification of robots.
2. Explain the working principles of robotic sensors and select suitable sensors for robotic applications.
3. Analyze robot drive and actuation systems.
4. Develop basic robot programs and control strategies.
5. Discuss robotic applications for industrial use.

UNIT I: INTRODUCTION — **08 Hrs.**

Definitions, history of robotics, benefit of robot, need of robot, laws of robotics, robot anatomy, types of robot, coordinate system, work envelope, robot specifications, robot parts and their functions, wrist and orientation.

UNIT II: SENSORS IN ROBOTICS — **08 Hrs.**

Definition of sensors, requirement of sensors, characteristics of sensors, classifications of sensors, **Internal Sensors**: Position sensors (Potentiometers, Encoders, LVDT), Velocity sensors (Tachometer, Hall effect sensor), acceleration sensors, **External Sensors:** Tactile (Touch sensors and force sensors), Proximity (Inductive, capacitive, ultrasonic), Range Sensors (LiDAR and IR sensors).

UNIT III: ROBOT ACTUATION AND DRIVE SYSTEMS — **08 Hrs.**

Definition, factors considered for selecting drive system, actuators, types of actuators: **Electric Drives:** Stepper motors, DC Servo motors, and BLDC motors; selection criteria for torque and speed. **Fluid Power:** Principles of Pneumatic and Hydraulic actuators; applications in industries.Comparison of pneumatic, hydraulic electrical drives. **Transmission Systems:** Gear transmission, Belt drives, Rollers, chains, Links, Linearto-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearings.

UNIT IV: ROBOT CONTROL AND PROGRAMMING — **08 Hrs.**

Open-loop vs. Closed-loop systems; basic concepts of PID control for joint stability, Point-to-Point (PTP) vs. Continuous Path (CP) motion, methods for robot programming**:** Lead-through, textual, and Off-line programming defining a program, Method of defining position in space, Motion interpolation, Basic

programming commands in workcell control (wait, signal and delay commands), Branching, Robot programming languages, Structure of robot language, VAL programming.

UNIT V: APPLICATIONS OF INDUSTRIAL ROBOT	**08 Hrs.**

Manufacturing applications of robot: Material handling, Machine loading / unloading, Spray painting, Welding, Machining, Assembly, pick and place, Inspection. **Non manufacturing robotic applications:** Hazardous environment, Medical, Mining, Space, Defence, Security, Domestic, Entertainment, Agriculture, Distribution and others; Future of robotics. **Case Study for Robotic Applications** including Robot Selection considerations for a typical industrial application.

TEXT BOOKS:

1. S.K. Saha, *Introduction to Robotics*, McGraw Hill Education.
2. R.K. Mittal & I.J. Nagrath, *Robotics and Control*, Tata McGraw Hill.

REFERENCE BOOKS:

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson Education.
2. Saeed B. Niku, *Introduction to Robotics: Analysis, Control, Applications*, Wiley.
3. Mikell P. Groover, *Industrial Robotics: Technology, Programming, and Applications*, McGraw Hill.

SEMESTER IV

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TP0407-2	**Kinematics of Robots**				MDM
Contact Hours per Week			**CA**	**ESE**	**Credits**
L	**P**	**Total**			
03	00	03	50+50	50	**03**

Prerequisites:

Students should have:

1. Basic knowledge of Mathematics, including linear algebra (matrices), trigonometry, and calculus.
2. Understanding of Engineering Mechanics, especially rigid body motion and coordinate systems.
3. Familiarity with vector operations and coordinate geometry in 2D and 3D space.
4. Basic understanding of mechanisms and machine kinematics.
5. Fundamental knowledge of programming or computational tools (MATLAB/Python) for numerical analysis.

Course Objectives:

After completing this course, students will be able to:

1. Understand and apply coordinate transformations and frame mapping for representing robotic systems.
2. Develop forward kinematic models of robotic manipulators using D-H parameters.
3. Formulate and solve inverse kinematics problems for different robotic configurations.
4. Analyze velocity relationships, Jacobian matrix, and singularities in robotic manipulators.
5. Model and analyze robot dynamics and trajectory planning for controlled motion.

Course Outcomes (CO)

After successful completion of the course, students will be able to:

1. Apply coordinate frame transformations and homogeneous matrices to represent position and orientation of robotic systems.
2. Develop and analyze forward kinematics models of manipulators using Denavit–Hartenberg (D-H) convention.
3. Solve inverse kinematics problems and evaluate multiple solutions, singularities, and workspace constraints.
4. Analyze Jacobian matrices, velocity relationships, and manipulability of robotic systems.
5. Formulate dynamic models and trajectory plans for robotic manipulators using Lagrangian and Newton–Euler methods.

UNIT I: Coordinate Frames, Mapping & Transforms	**08 Hrs.**

Significance of Coordinate Frames, Mapping & Transforms in robotics. Description of object in space, Mapping between rotated frames, translated frame and combined rotation & translation. Homogeneous transformation, Difference between fixed & movable frame, Composite/multiple transformation, Fixed angle rotation and Euler angle rotation.

UNIT II: Forward Kinematics of Robot	**08 Hrs.**

Introduction manipulator kinematics, Mechanical structure and notation, Description of links and joints, kinematic modelling of the manipulator, Difference between direct and inverse kinematics, Denavit-Hartenberg (D-H) notation and algorithms, Kinematic relationship between adjacent link, Manipulator Transformation Matrix, Workspace analysis.

UNIT III: Inverse Kinematics of Robot	**08 Hrs.**

Problem formulation of inverse kinematics, Analytical and numerical methods, Closed-form solutions for simple manipulators (2R and 3R planer), Redundant manipulators, Multiple solutions and singular configurations, Workspace and reachability analysis

UNIT IV: Jacobian and Singularity Analysis	**8 Hrs.**

Linear and angular velocity of a rigid body, relationship between transformation matrix and angular velocity, Jacobian matrix and its significance, Jacobian inverse, Jacobian Singularity, Manipulability, Dexterity analysis of manipulators, Redundancy and its impact on kinematic performance.

UNIT V: Dynamic modelling & Trajectory planning	**8 Hrs.**

Lagrangian mechanics, Dynamic model of n-DOF manipulator, Lagrange-Euler and Newton-Euler formulation to dynamic solution. Inverse Dynamics, Terminology related to trajectory planning, trajectory planning to determine the joint velocity and acceleration.

TEXT BOOKS:

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
2. Craig J. J., Introduction to Robotics: Mechanics and Control, 3rd Edition, Addison-Wesley, Reading, MA, 2005.
3. Odrey, Mikell P. Groover& Nicholas G., Mitchel Weiss, Roger N. Nagel, and Ashish Dutta. "Industrial Robotics,
4. Technology programming and Applications.", McGraw Hill Education; 2nd edition (July 2017).

REFERENCE BOOKS:

- P. A. Janaki Raman, Robotics and Image Processing An Introduction, Tata MCGraw Hill Publishing company Ltd., 1995.
- Shames I. H., Engineering Mechanics- Statics and Dynamics" $/e Prentice-Hall of India Pvt. Ltd., 2005.

Course Code	Course Title	Category

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

26ES03TH0507	Mobile Robotics Semester VI				MDM
Contact Hours per Week			CA	ESE	Credits
L	P	Total			
03	00	**03**	50	50	03

Prerequisite: Basics of Robotics, Engineering Mathematics (Matrices, Probability basics)

Course Description: This course introduces the fundamentals of robotics with an emphasis on mobile robots, which are integrated mechanical, electrical and computational systems functioning in the physical world. The course aims to provide both theoretical and practical experience to students through lectures and hands-on experiments with real robots and simulation software.

Course Objectives: This course will present various aspects of design, fabrication, motion planning, and control of intelligent mobile robotic systems.

1. To introduce fundamentals of mobile robots, locomotion, and hardware components.
2. To develop understanding of kinematics, dynamics, and motion constraints.
3. To provide knowledge of perception, sensing, and uncertainty handling.
4. To explain localization, mapping, and navigation techniques.
5. To expose students to path planning algorithms and intelligent robot design.

Course Outcomes: On successful completion of the module students will be able to:

1. *Explain* mobile robot types, locomotion mechanisms, and performance characteristics.
2. *Apply* kinematic and dynamic models to analyze motion of mobile robots.
3. *Analyze* sensor characteristics and perception techniques under uncertainty.
4. *Apply* localization methods to estimate robot position in uncertain environments.
5. *Evaluate* path planning and navigation algorithms for intelligent mobile robots.

UNIT I: FUNDAMENTALS OF MOBILE ROBOTICS	**08 Hrs.**

Introduction to mobile robots, classification (wheeled, legged, aerial). Applications in industrial and service domains. Locomotion principles,Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability, degrees of freedom, holonomic and non-holonomic systems. Overview of robot components: sensors, actuators, controllers.

UNIT II: KINEMATICS OF MOBILE ROBOTS	**08 Hrs.**

Kinematic modeling of wheeled mobile robots: differential drive and car-like robots. Coordinate frames and transformations, robot pose representation. Forward kinematics and basic motion constraints. Odometry and dead reckoning.

UNIT III: PERCEPTION	**08 Hrs.**

Sensors Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision-based sensors, uncertainty in sensing, filtering.

UNIT IV: LOCALIZATION	**08 Hrs.**

Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems;

UNIT V: PATH PLANNING AND NAVIGATION	**08 Hrs.**
Introduction, Path Planning, offline and online path planning, obstacle avoidance, path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), Potential field etc. Advanced Topics: AI based techniques for navigation, Bio Inspired Algorithm, Multiple robot coordination. Design of intelligent robots	
TEXT BOOKS: 1. Siegwart, Nourbakhsh, Scaramuzza – *Introduction to Autonomous Mobile Robots* 2. Dudek & Jenkin – *Computational Principles of Mobile Robotics*	
REFERENCE BOOKS: Thrun, Burgard, Fox – *Probabilistic Robotics* Howie Choset – *Principles of Robot Motion* *Selected readings from the research literature, to be distributed in class.*	

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TH0607	**Drone Technology**				**MDM**
Contact Hours per Week			**CA**	**FE**	**Credits**
L	P	**S**			
03	01	00	50	50	03

Prerequisite: Basic Robotics, Mechanics

Course Objectives:

1. To introduce fundamentals of UAV systems, classifications, and aerodynamics.
2. To develop understanding of UAV components, sensors, and propulsion systems.
3. To explain flight dynamics, control, and stabilization techniques.
4. To provide knowledge of navigation, path planning, and autonomous operation.
5. To expose students to UAV applications, regulations, and emerging trends.

Course Outcomes: On successful completion of the module students will be able to:

1. Explain UAV types, components, and aerodynamic principles.
2. Analyze UAV propulsion and hardware systems**.**
3. Apply flight dynamics and control strategies for UAV stabilization.
4. Apply navigation and path planning techniques for autonomous UAVs.
5. Evaluate UAV applications, regulations, and system performance.

UNIT I: INTRODUCTION TO UAV SYSTEMS	**08 Hrs.**

Definition and history of UAVs, classification (fixed-wing, rotary-wing, hybrid UAVs). Basic aerodynamics: lift, drag, thrust, and stability. UAV architecture and subsystems overview. Applications in defense, agriculture, logistics, surveillance, and disaster management.

UNIT II: UAV COMPONENTS AND PROPULSION	**08 Hrs.**

UAV hardware: frame, motors (BLDC), ESC, propellers, batteries. Sensors: IMU, GPS, barometer, magnetometer. Flight controllers and communication modules. Propulsion systems and power requirements. Payload integration and weight considerations.

UNIT III: FLIGHT DYNAMICS AND CONTROL	**08 Hrs.**

Equations of motion for UAVs (basic). Stability concepts: roll, pitch, yaw control. PID control for UAV stabilization. Attitude estimation using IMU. Introduction to advanced control (LQR, adaptive control). Flight modes and autopilot systems.

UNIT IV: NAVIGATION AND AUTONOMOUS FLIGHT	**08 Hrs.**

Waypoint navigation, trajectory generation. Path planning algorithms (A*, RRT). Sensor fusion for localization (GPS + IMU). Obstacle detection and avoidance. Introduction to SLAM for UAVs. Autonomous mission planning.

UNIT V: UAV APPLICATIONS, REGULATIONS AND FUTURE TRENDS	**08 Hrs.**

Applications: precision agriculture, mapping, delivery drones, surveillance. UAV regulations (DGCA guidelines in India), safety and ethical issues. Swarm drones and AI integration. Emerging trends: drone

taxis, autonomous fleets, BVLOS operations.

TEXT BOOKS:

1. Austin, R. – Unmanned Aircraft Systems: UAV Design, Development and Deployment
2. Kimon P. Valavanis & George Vachtsevanos – Handbook of Unmanned Aerial Vehicles
3. Anderson, J. D. (2021). Introduction to Flight (9th ed.). McGraw-Hill Education.

REFERENCE BOOK:

Paul Fahlstrom & Thomas Gleason – *Introduction to UAV Systems*

Small Unmanned Aircraft: Theory and Practice" by Randal W. Beard and Timothy W. McLain.

MOOC COURSES:

Coursera: Aerial Robotics (University of Pennsylvania).

PX4 Autopilot Documentation

MIT Open Course Ware UAV lectures

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

HONORS

Course Code	Course Title	Category

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

26ES03HT0301	Field & Service Robot Semester III				Honor
Contact Hours per Week			CA	FE	Credits
L	P	S			
3	0	1	50	50	3

Prerequisite: Nil

Course Objectives:

1. To understand the requirements and constraints of field and service robotics.
2. To explore real-world case studies in agriculture, defense, underwater and healthcare applications.

Course Outcomes: On successful completion of the module students will be able to:

1. Learn basic terminology and application of industrial robots.
2. Understand and apply the application of Underwater, Aerial and Space Robots
3. Understand and apply the application of Agriculture, Construction and Mining Robots
4. Understand and apply the application of Domestic and Medical Robotics
5. Understand and apply the application Humanoids and Intelligent Vehicles

UNIT I: INTRODUCTION TO FIELD & SERVICE ROBOTS — **08 Hrs.**

History and evolution of robotics, laws of robotics, robots, robot subsystems, robot configurations, classification of robots, Typical applications- welding, assembly, painting, automated material transfer, machining, human-robot cooperation for handling tasks.

UNIT II: UNDERWATER, AERIAL AND SPACE ROBOTICS — **08 Hrs.**

Introduction to underwater robotics, historical background, sensor systems, actuating systems, applications. Introduction to aerial robotics, historical background, unmanned aerial vehicles, quadrotors, components of autonomous flight, applications and challenges of aerial robotics. Introduction to space robotics, historical background, orbital robotics systems, surface robotic systems, applications and examples.

UNIT III: AGRICULTURE, CONSTRUCTION AND MINING ROBOTICS — **08 Hrs.**

Introduction to agricultural robotics, overview of the agricultural robots, typical applications, challenges of the field. Introduction to robotics in construction, system overview, basic types of construction robots, economic aspects, applications. Introduction to robotics in mining, historical background, applications in mining process.

UNIT IV: DOMESTIC AND MEDICAL ROBOTICS — **08 Hrs.**

Introduction to home automation, domestic robotics, cleaning robots, lawn moving robots, challenges and applications. Introduction to medical robotics, historical background, surgical robots, rehabilitation robots, exoskeletons, issues related to safety and ethics, applications and challenges in medical robotics.

UNIT V: HUMANOIDS AND INTELLIGENT VEHICLES — **08 Hrs.**

Introduction to humanoids, historical background, locomotion and manipulation of humanoids, whole body activities, teaching methodologies, applications. Concept of intelligence, need and necessity of intelligent vehicles, driver assistance systems, driver monitoring systems, road scene interpretation, automated vehicles, applications and challenges.

TEXT BOOKS:

1. Robin Murphy, 'Introduction to AI Robotics', MIT Press.
2. Roland Siegwart, 'Autonomous Mobile Robots', MIT Press.
3. R. K. Mittal and I. J. Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.

REFERENCE BOOKS:

1. Yoseph Bar-Cohen, 'Robotics for Challenging Environments', ASCE Publications.
2. Norihiko Takahashi, 'Service Robot Applications', InTech.

Course Code	Course Title		Category
26ES03HT0401	Advanced Sensors and Actuators Semester IV		Honors
Contact Hours per Week	CA	ESE	Credits

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

L	T	S			
03	00	00	50	50	03

Prerequisite:

Students should be familiar with fundamental concepts of Physics such as electricity, magnetism, and mechanics. A basic understanding of electrical and electronic circuits, including analog and digital electronics, is essential.

Students should also have prior knowledge of basic transducers, signal conditioning, and basic control principles. Familiarity with microcontrollers, embedded systems, and basic programming concepts will be beneficial.

Course Objectives:

1. To develop a strong foundation in the principles of sensors, actuators, and energy transformation mechanisms.
2. To provide knowledge of microfabrication techniques and working principles of microsensors and microactuators used in modern engineering applications.
3. To enable students to design, interface, simulate, and evaluate sensor-based systems, including signal conditioning, characterization, and performance analysis.

Course Outcomes:

After completion of the course, students will be able to:

1. Explain working principles of different sensors and actuators.
2. Analyze microfabrication processes used in sensor design.
3. Apply knowledge to design basic microsensors and actuator systems.
4. Evaluate sensor performance using static and dynamic characteristics.
5. Develop simple sensor-based systems with interfacing and simulation tools.

UNIT I: Fundamentals of Sensors and Energy Transformation	**08 Hrs.**

Introduction to sensors, transducers, and actuators, Classification of sensors (active/passive, analog/digital),Energy transformation principles in sensing systems ,Static and dynamic characteristics of sensors,Performance parameters: sensitivity, accuracy, precision, hysteresis ,Introduction to microsensors and MEMS technology ,applications in industrial, biomedical, and environmental systems

UNIT II: Microfabrication Techniques and Thin Film Technology	**08 Hrs.**

Basics of thin film physics and material properties, Overview of MOSFET and its relevance in sensing , Chemical Vapor Deposition (CVD): APCVD, LPCVD, PECVD, MOCVD , Physical Vapor Deposition (PVD): evaporation, sputtering, PLD ,Photolithography process and mask design, Etching techniques: wet etching and dry etching,Cleanroom practices and fabrication challenges

UNIT III: Advanced Microsensors	**8 Hrs.**

Gas sensors: MOS, optical, polymer-based, nanostructured sensors,Electrochemical sensors: principles and applications, Mechanical sensors: pressure, force, strain gauges , Thermal and optical sensors , Biosensors and biomedical applications ,Case studies of modern sensor technologies.

UNIT IV: Microactuators and Microfluidic Systems	**8 Hrs.**
Fundamentals of actuators and actuation mechanisms,Piezoelectric and piezoresistive actuators, Electrostatic and thermal actuators, Micropumps and microfluidic devices, PDMS fabrication, moulding, and bonding techniques,Applications in lab-on-chip and biomedical systems	
UNIT V: Sensor Interfacing, Simulation and Characterization	**8 Hrs.**
Signal conditioning circuits: amplification, filtering, Sensor interfacing with microcontrollers and processors , Data acquisition systems, Simulation tools: Introduction to COMSOL Multiphysics , Modeling and optimization of sensors, Calibration techniques, Static and dynamic performance evaluation	
Textbooks 1. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms by Nikolaus Correll (Author), Bradley Hayes (Author), Christoffer Heckman (Author), Alessandro Roncone, The MIT Press, 2022. 2. Sensors and Actuators: Control System Instrumentation" by C.W. de Silva, CRC Press, Taylor and Francis, 2007.	
Reference Books 1. The Mechatronics Handbook, Robert H. Bishop, CRC Press, 2002	

Course Code	**Course Title**		**Category**
26ES03HT0501	**Mobile and Micro Robotics** **Semester V**		Honor
Contact Hours per Week	**CA**	**FE**	**Credits**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

L	P	S			
4	**0**	**1**	**50**	**50**	**4**

Prerequisite: Fundamentals of Robotics**,** Field & Service Robot

Course Objectives:

1. To introduce the fundamentals of mobile and micro robotics and their unique design challenges.
2. To develop understanding of locomotion, actuation, sensing, and control at micro scale.
3. To explain power and communication constraints in micro-robotic systems.
4. To expose students to real-world applications and emerging trends in micro robotics.

Course Outcomes: On successful completion of the module students will be able to:

1. Explain concepts, challenges, and applications of mobile and micro robots.
2. .Analyze locomotion and actuation mechanisms for micro-robot systems.
3. .Apply sensing and control techniques in micro-robotic environments.
4. Evaluate power and communication strategies for efficient micro-robot operation.
5. Design a basic micro-robotic solution for a given application.

UNIT I: INTRODUCTION TO MOBILE AND MICRO ROBOTS **08Hrs.**

Overview of micro robotic applications, size constraints, locomotion mechanisms at micro scale, challenges in miniaturization. Comparison between macro and micro robots in terms of design, mobility and application domains. Regulatory challenges in micro-robot deployments.

UNIT II: LOCOMOTION AND ACTUATION **08 Hrs.**

Locomotion mechanisms: wheeled, legged, snake-like, and bio-inspired systems. Micro-scale actuation: piezoelectric, electrostatic, magnetic, and soft actuators. Hybrid mobility systems and compliant mechanisms. Performance comparison and selection of actuation techniques.

UNIT III: SENSING AND CONTROL **8 Hrs.**

MEMS-based sensors, minimal sensing strategies, and sensor integration. On-board vs external control, embedded controllers for micro robots. Sensor noise, filtering techniques, and basic control strategies. Wireless sensing and decentralized control concepts.

UNIT IV: POWER AND COMMUNICATION **8 Hrs.**

Energy sources: micro batteries, energy harvesting, and wireless charging. Power density and energy management strategies. Communication techniques: RF, optical, and magnetic. Design considerations for low-latency and reliable communication in micro systems.

UNIT V: APPLICATIONS AND CASE STUDIES **8 Hrs.**

Applications in medical, surveillance, precision agriculture, and hazardous environments. Bio-inspired and swarm micro-robot systems. Case studies of recent research developments and performance evaluation.

TEXT BOOKS:

1. Bradley Nelson, 'Micro and Nano Robotics', Springer.
2. Gregory Dudek, Michael Jenkin, 'Computational Principles of Mobile Robotics', Cambridge.

REFERENCE BOOKS:

1. Paolo Dario, 'Microrobotics for Biomedical Applications', Springer.
2. Recent IEEE Transactions on Robotics and Mechatronics papers.

MOOC COURSES:

1. Coursera: Nanorobotics – https://www.coursera.org/learn/nanorobotics
2. edX: Introduction to Soft Robotics – https://www.edx.org/course/soft-robotics

Course Code	Course Title				Category
24ES03HT0601	Multi-Robot Systems and Swarm Intelligence Semester VI				Honor
Contact Hours per Week			CA	FE	Credits
L	P	S			

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

4	**0**	**1**	**50**	**50**	**4**

Prerequisite: Mobile and Micro Robotics

Course Objectives:

1. To introduce the fundamentals and taxonomy of multi-robot and swarm systems.
2. To develop understanding of coordination, formation, and motion planning strategies.
3. To explain swarm intelligence principles and distributed control mechanisms.
4. To expose students to real-world applications and simulation tools for multi-robot systems.

Course Outcomes: On successful completion of the module students will be able to:

1. Explain taxonomy, communication, and coordination strategies in multi-robot systems.
2. Apply formation control and motion planning techniques for multi-robot navigation.
3. Analyze swarm intelligence principles and bio-inspired algorithms.
4. Evaluate distributed control and consensus strategies in multi-robot systems.
5. Evaluate applications and tools for multi-robot system deployment.

UNIT I: INTRODUCTION TO MULTI-ROBOT SYSTEMS	**08 Hrs.**

Taxonomy of multi-robot systems, task allocation, coordination vs cooperation, communication models. Detailed taxonomy: homogeneous vs heterogeneous swarms, direct vs indirect communication.

UNIT II: FORMATION AND MOTION PLANNING	**08 Hrs.**

Flocking, formation keeping, leader-follower models, Behavior-based design methods, navigation in dynamic environments, application of flocking in aerial vehicles.

UNIT III: SWARM INTELLIGENCE BASICS	**8 Hrs.**

Inspiration from natural swarms, stigmergy, bio-inspired rules, emergent behavior. Algorithms inspired by ants, bees and fish; emergent collective behavior under minimal rules.

UNIT IV: DISTRIBUTED CONTROL AND CONSENSUS	**8 Hrs.**

Decentralized systems, consensus algorithms, fault tolerance, robustness in swarm. Impact of latency and communication failures, robustness against individual failure, real-time consensus strategies.

UNIT V: APPLICATIONS AND TOOLS	**8 Hrs.**

Exploration, search and rescue, warehouse automation, simulation tools: ARGoS, Webots, ROS multi-robot packages. Comparative analysis of simulation platforms, integration with physical robot swarms, human-swarm interaction.

TEXT BOOKS:

1. Brambilla, M., 'Swarm Robotics: A Review from the Swarm Engineering Perspective', Springer.
2. Bayındır, L., 'A review of swarm robotics tasks', Elsevier.Bradley Nelson, 'Micro and Nano Robotics', Springer.

REFERENCE BOOKS:

1. Sahin, E., and Spears, W. M., 'Swarm Robotics Workshop Proceedings', Springer.
2. Recent publications from IROS and ICRA conferences.

Ramdeobaba University, Nagpur

Department of Mechanical Engineering, School of Engineering Sciences

Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence

Session: 2026-27

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Minors

Course Code	Course Title				Category
26ES03MT0301	**Introduction to Robotics Semester III**				Minor
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
3	**0**	**1**	**50**	**50**	**3**

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Prerequisite: Nil

Course Objectives:

1. To introduce fundamental concepts, history, and classifications of robotics.
2. To develop understanding of key components of robotic systems.
3. To explain robot configurations, workspace, and basic kinematics.
4. To provide exposure to basic robot programming and applications.

Course Outcomes: On successful completion of the module students will be able to:

1. Explain fundamentals, classification, and applications of robotics systems.
2. Identify and select appropriate components of robotic systems for given tasks.
3. Analyze robot configurations and workspace characteristics.
4. Apply basic kinematic concepts to determine end-effector position.
5. Demonstrate basic robot programming and evaluate applications.

UNIT I: INTRODUCTION	**8 Hrs.**

Definition, history and scope of robotics, classification of robots, serial vs parallel robots, service vs industrial robots, role of AI in robotics. Evolution of robotics from mechanical automata to intelligent systems, interdisciplinary nature of robotics, applications in manufacturing, healthcare, exploration.

UNIT II: COMPONENTS OF ROBOTIC SYSTEMS	**8 Hrs.**

Links, joints, actuators, end-effectors, sensors, drive systems (electric, pneumatic, hydraulic), power supplies and controllers. Joint mechanisms (revolute, prismatic), torque vs speed tradeoffs in actuators, roles of sensors in closed-loop control.

UNIT III: ROBOT CONFIGURATIONS AND WORKSPACE	**8 Hrs.**

Common robot architectures: Cartesian, cylindrical, spherical, SCARA, and articulated arms; degrees of freedom; workspace analysis. Forward reach, dexterity, manipulability, real-world examples of various robot arms.

UNIT IV: KINEMATICS BASICS	**8 Hrs.**

Coordinate frames, transformation matrices, D-H convention basics, forward kinematics of simple manipulators. Derivation of transformation matrices, effect of joint movements on end-effector position.

UNIT V: INTRODUCTORY PROGRAMMING AND APPLICATIONS	**8 Hrs.**

Lead-through programming, path control, pick and place logic, simulation environments, industrial and domestic robot applications. Programming syntax for industrial robots, offline simulation tools, real vs virtual environments.

TEXT BOOKS:

1. Craig, J. J., 'Introduction to Robotics: Mechanics and Control', Pearson.
2. Groover, M. P., 'Industrial Robotics: Technology, Programming, and Applications', McGraw-Hill.

REFERENCE BOOKS:

1.]R. K. Mittal and I. J. Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi.
2. Niku, S. B., 'Introduction to Robotics: Analysis, Control, Applications', Wiley.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03MT0401	**Field & Service Robot Semester III**				Minor
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
3	**0**	**1**	**50**	**50**	**3**

Prerequisite: Nil

Course Objectives:

1. To understand the requirements and constraints of field and service robotics.
2. To explore real-world case studies in agriculture, defense, underwater and healthcare applications.

Course Outcomes: On successful completion of the module students will be able to:

1. Learn basic terminology and application of industrial robots.
2. Understand and apply the application of Underwater, Aerial and Space Robots
3. Understand and apply the application of Agriculture, Construction and Mining Robots
4. Understand and apply the application of Domestic and Medical Robotics
5. Understand and apply the application Humanoids and Intelligent Vehicles

UNIT I: INTRODUCTION TO FIELD & SERVICE ROBOTS	**08 Hrs.**
History and evolution of robotics, laws of robotics, robots, robot subsystems, robot configurations, classification of robots, Typical applications- welding, assembly, painting, automated material transfer, machining, human-robot cooperation for handling tasks.	
UNIT II: UNDERWATER, AERIAL AND SPACE ROBOTICS	**08 Hrs.**
Introduction to underwater robotics, historical background, sensor systems, actuating systems, applications. Introduction to aerial robotics, historical background, unmanned aerial vehicles, quadrotors, components of autonomous flight, applications and challenges of aerial robotics. Introduction to space robotics, historical background, orbital robotics systems, surface robotic systems, applications and examples.	
UNIT III: AGRICULTURE, CONSTRUCTION AND MINING ROBOTICS	**08 Hrs.**
Introduction to agricultural robotics, overview of the agricultural robots, typical applications, challenges of the field. Introduction to robotics in construction, system overview, basic types of construction robots, economic aspects, applications. Introduction to robotics in mining, historical background, applications in mining process.	
UNIT IV: DOMESTIC AND MEDICAL ROBOTICS	**08 Hrs.**
Introduction to home automation, domestic robotics, cleaning robots, lawn moving robots, challenges and applications. Introduction to medical robotics, historical background, surgical robots, rehabilitation robots, exoskeletons, issues related to safety and ethics, applications and challenges in medical robotics.	
UNIT V: HUMANOIDS AND INTELLIGENT VEHICLES	**08 Hrs.**

Introduction to humanoids, historical background, locomotion and manipulation of humanoids, whole body activities, teaching methodologies, applications. Concept of intelligence, need and necessity of intelligent vehicles, driver assistance systems, driver monitoring systems, road scene interpretation, automated vehicles, applications and challenges.

TEXT BOOKS:

1. Robin Murphy, 'Introduction to AI Robotics', MIT Press.
2. Roland Siegwart, 'Autonomous Mobile Robots', MIT Press.
3. R. K. Mittal and I. J. Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.

REFERENCE BOOKS:

1. Yoseph Bar-Cohen, 'Robotics for Challenging Environments', ASCE Publications.
2. Norihiko Takahashi, 'Service Robot Applications', InTech.

Course Code	Course Title				Category
26ES03MT0501	**Industrial Automation Semester IV**				
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
4	**0**	**1**	**50**	**50**	**4**

Prerequisite: Basic Electrical and Mechanical Engineering

Course Objectives:

1. To introduce the fundamentals and interdisciplinary nature of mechatronics systems.
2. To develop understanding of sensors, actuators, and their selection for engineering applications.
3. To provide knowledge of controllers and interfacing techniques used in automation.
4. To enable analysis and design of basic mechatronic and automation systems.

Course Outcomes: On successful completion of the module students will be able to:

1. Explain the concept, scope, and applications of mechatronics systems.
2. Select and compare sensors and transducers for given applications.
3. Analyze and choose suitable actuators and drivers based on system requirements.
4. Apply microcontroller/PLC concepts to develop basic interfacing and control logic.
5. Evaluate automation systems and propose suitable mechatronic solutions.

UNIT I: INTRODUCTION TO MECHATRONICS	**08 Hrs.**

Definition and scope, interdisciplinary nature, system approach, mechatronics in product design, evolution of automation. Examples of mechatronic systems: automatic doors, washing machines, 3D printers.	
UNIT II: SENSORS AND TRANSDUCERS	**08 Hrs.**
Types of sensors – temperature, pressure, proximity, vision, and motion; signal conditioning; selection criteria. Working principles of capacitive, resistive, and inductive sensors, smart sensors with built-in processors.	
UNIT III: ACTUATORS AND DRIVERS	**08 Hrs.**
DC, stepper and servo motors, hydraulic and pneumatic actuators, H-bridge and motor drivers, PWM control. Selection of motors based on torque/speed/load, practical interfacing circuits and protection strategies.	
UNIT IV: CONTROLLERS AND INTERFACING	**08 Hrs.**
Microcontrollers (Arduino, STM), PLCs, basics of embedded C, ladder logic, interfacing I/O devices, timers, counters. Real-time clock use, PWM techniques, interrupt handling in microcontrollers.	
UNIT V: AUTOMATION CASE STUDIES	**08 Hrs.**
Assembly line automation, smart home automation, robotic arms, packaging systems, and real-time control implementation. Case study of sorting conveyor, bottling line control, elevator control system using ladder logic.	

TEXT BOOKS:

1. Bolton, W., 'Mechatronics', Pearson
2. Alciatore, D. G., Histand, M. B., 'Introduction to Mechatronics and Measurement Systems', McGraw-Hill.

REFERENCE BOOKS:

1. Mahalik, N. P., 'Mechatronics: Principles, Concepts and Applications', TMH.
2. Groover, M. P., 'Automation, Production Systems and Computer Integrated Manufacturing', Pearson.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Code	Course Title				Category
26ES03TH0601	**Robot safety, maintenance and standards**				Minor
Contact Hours per Week			**CA**	**FE**	**Credits**
L	**P**	**S**			
04	0	1	50	-	**04**

Prerequisites

Students should have:

1. Basic understanding of **robotics and automation systems**.
2. Knowledge of **engineering mechanics and machine elements**.
3. Familiarity with **electrical and electronic components** used in robots.
4. Basic understanding of **control systems and sensors**.

Course Objectives

After completing this course, students will be able to:

1. Understand **safety principles, hazards, and risk assessment** in robotic systems.
2. Apply **industrial safety standards and regulatory requirements**.
3. Develop knowledge of **maintenance strategies and troubleshooting techniques**.
4. Analyse **reliability, failure modes, and lifecycle safety** of robotic systems.

Ramdeobaba University, Nagpur
Department of Mechanical Engineering, School of Engineering Sciences
Teaching and Evaluation Scheme B.Tech. in Robotics and Artificial Intelligence
Session: 2026-27

Course Outcomes (CO)

After successful completion of the course, students will be able to:

1. Identify and assess **hazards and risks** in robotic systems and work environments.
2. Apply relevant **robot safety standards and compliance requirements**.
3. Plan and perform **maintenance, diagnostics, and troubleshooting** of robotic systems.
4. Analyze **reliability, failure modes, and implement safe lifecycle practices**.

Unit I: Robot Safety Fundamentals and Risk Assessment	**08 Hrs.**

Importance of safety in robotics and automation, Types of hazards: mechanical, electrical, thermal, environmental, Risk assessment techniques and hazard identification, Safety in human-robot interaction (HRI), Workspace design: safety zones, guarding, interlocks.

Unit II: Safety Standards and Regulatory Compliance	**08 Hrs.**

Overview of international standards (ISO, ANSI, IEC), Key standards: ISO 10218 (industrial robot safety), ISO/TS 15066 (collaborative robots), Machine safety directives and compliance procedures, Certification, documentation, and legal considerations.

Unit III: Maintenance and Diagnostics of Robotic Systems	**08 Hrs.**

Types of maintenance: preventive, predictive, corrective, Maintenance planning and scheduling, Inspection, lubrication, and calibration, Condition monitoring and fault diagnostics, Troubleshooting techniques

Unit IV: Reliability, Failure Analysis and Safety Integration	**08 Hrs.**

Reliability concepts (MTBF, MTTR), Failure modes and effects analysis (FMEA), Root cause analysis and risk mitigation, Fail-safe design and emergency systems, Safety integration in robotic cells and lifecycle management, Case studies of industrial robot safety

Textbooks:

1. Dhillon, B.S., Robot System Reliability and Safety: A Modern Approach, CRC Press, 2015.
2. Starr, J. & Quick, C., Robotic Safety Systems: An Applied Approach, CRC Press, 2024.

Reference Books

3. Etherton, J.R., Safe Maintenance Guide for Robotic Workstations, DIANE Publishing, 1994.
4. Nof, S.Y., Handbook of Industrial Robotics, Wiley.