भारतीय प्रौद्योगिकी संस्थान भुवनेश्वर
INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR
शैक्षणिक अनुभाग /Academic Section

15-62/2025-Acad/Minutes-69th **दिनांक/dated. 31 July, 2026**

कार्यालय आदेश सं./Office Order No. 451 / 2026

Senate : 69th Meeting held on 13th April, 2026

Sub. : Approval for new certificate course "Professional PG Diploma in Advanced Robotics with Artificial Intelligence" (OPEC recommendation) – reg.

Ref. : Agenda Item No. 69.A.E.3

1. The undersigned is directed to convey that the Senate had referred back the proposal for collaboration with the Skill Development Institute (SDI), Bhubaneswar, for conducting skill-based training programmes for further review.
2. Subsequently, upon resubmission of the recommendation by the OPEC, the Competent Authority has approved the proposal for introducing a new certificate course, **"Professional PG Diploma in Advanced Robotics with Artificial Intelligence,"** to be offered jointly by IIT Bhubaneswar and SDI Bhubaneswar.

    a) The detailed course structure is enclosed as **Annexure-III**.

    b) The course approved by the Senate can be offered as certificate course and grades can be awarded as per regulation.

    c) The admission to those Certificate courses and their management i.e. registration, fee payment, etc will be managed by Continuing Education.

Jigyasha 31/07/2026

सहायक कुलसचिव (स्ना. और अ.का.) /
Assistant Registrar (PG & RP)

सेवा में /To

Committee Members

प्रतिलिपि/Copy to

1. Chairperson, Senate
2. All Members of the Senate
3. Dean –CE
4. All Heads of the Schools/Departments
5. Faculty Members
6. PS to Director
7. PS to Registrar
8. Office Order file

INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR
Bhubaneswar - 752050
School of Mechanical Sciences

Detailed Curriculum of Professional PG Diploma in Advanced Robotics with Artificial Intelligence

IIT Bhubaneswar and **Skill Development Institute (SDI),** Bhubaneswar, are proposing to offer a **Professional PG Diploma in Advanced Robotics with Artificial Intelligence**: a **one-year, two-semester residential program** designed to equip B.Tech graduates with the practical and theoretical competencies demanded by modern industry. The program is structured to leverage the academic strengths of both institutions: **students will reside at the SDI campus** and **attend theory classes at IIT Bhubaneswar in the evening, while hands-on laboratory training will be conducted at the SDI campus**.

Academic transcripts for theory courses will be issued by IIT Bhubaneswar, and transcripts for laboratory courses will be issued by SDI, ensuring that students receive dual institutional recognition for their learning. **The degree certificate will be awarded jointly by IIT Bhubaneswar and Skill Development Institute.** Residential accommodation will be arranged within the SDI campus, and the partnership will be formally governed by a separate Memorandum of Understanding (MoU) between the two institutions.

The **Skill Development Institute (SDI), Bhubaneswar**, is a premier vocational training organisation established under the Ministry of Petroleum and Natural Gas, Government of India, with a strong mandate to develop industry-ready technical manpower in collaboration with your industries. With state-of-the-art workshops, well-equipped laboratories, and experienced industry-trained instructors, SDI Bhubaneswar has a proven track record of bridging the gap between academic knowledge and industrial application. Its infrastructure, industry linkages, and focus on competency-based training make it an ideal partner for delivering the laboratory and practical components of this advanced program, ensuring that graduates are thoroughly prepared for employment in robotics, automation, and AI-driven industrial environments.

SDI Industrial partners/collaborators: M/S Schneider Electric, M/S Siemens Industry Software (India) Pvt. Ltd., M/S Kemppi (For Welding CoE), M/S Lixil (For Plumbing CoE)

Program Coordinators IITBBS: Prof. Pandu Ranga V & Dr. Venugopal Arumuru
Program Coordinators SDI: Mr Nihar Ranjan Das, DGM(T), SDI-Bhubaneswar

Course Structure and Syllabus

Semester 1				
Sl. No.	Course No.	Course Name	L-T-P	C
1	AR6L101	Robotics	3-1-0	4
2	AR6L102	Electro Pneumatics and Hydraulics	3-0-0	3
3	AR6L103	Computer-Aided Design & Manufacturing	3-0-0	3
4	AR6P101	Python Laboratory	0-0-3	2
5	AR6P102	Industrial Robotics Laboratory	0-0-3	2
6	AR6P103	Electro Pneumatics and Hydraulics Laboratory	0-0-3	2
6	AR6P104	CAD/CAM Laboratory	0-0-3	2
7	AR6D101	Mini Project	----	4
Total L-T-P and Credit			9-1-12	**22**
Semester 2				
Sl. No.	Course No.	Course Name	L-T-P	C
1	AR6L201	Engineering Measurements	3-1-0	4
2	AR6L202	Advanced Robotics	3-1-0	4
3	AR6L203	Robotics Vision and AI	3-1-0	4
4	AR6P201	Measurement and Instrumentation Laboratory	0-0-3	2
5	AR6P202	Advanced Robotics Laboratory	0-0-3	2
6	AR6P203	Robotics Vision Laboratory	0-0-3	2
7	AR6S201	Seminar	0-0-3	2
8	AR6D201	Project	----	8
Total L-T-P and Credit			9-2-12	**28**

Summary

Details	**Semester I**	**Semester II**	**Total Credits**
Theory Subjects	10	12	22
Lab. Subjects	8	6	14
Seminar	-	2	2
Project	4	8	12
Total Credits	**22**	**28**	**50**

Eligibility: First Class degree in Mechanical Engineering/Manufacturing/ Industrial Production Engineering/Mechatronics/ Robotics/ Electrical Engineering/ Electronics and Communication Engineering/Computer Science and Engineering/ B.Sc. Physics/ AI and ML or equivalent.

Selection: Written test consisting of Engineering Mathematics, Engineering Physics and General Aptitude

SEMESTER – I (Theory Courses offered by IITBBS)

1.	**Course Title:**	Robotics
2.	**Subject Code:**	AR6L101
3.	**L-T-P-:**	3-1-0
4.	**Credit:**	4
5.	**Semester No:**	1
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	4
8.	**Theory:**	4
9.	**(Autumn/ Spring):**	Autumn
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	None
12.	**Lab:**	None
13.	**Instructor(s):**	Prof. V Pandu Ranga

14. Syllabus:

Introduction to the role of a Robotics & Automation, what is and what is not a robot, Robot Anatomy, Classification of Robots, End effectors/Grippers and its design, programming, Industrial and Non-industrial applications of robots, Coordinate frames and transformations, Forward kinematics of manipulators, Inverse kinematics of manipulators, Differential motion, Dynamics modelling, Trajectory planning, Robot actuators and characteristics, Pneumatic, hydraulic and electric actuation systems, Robotic sensors and characteristics, Internal sensors, External sensors.

15. Learning Outcomes:

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

- Explain the role of Robotics & Automation, robot anatomy, classification, and applications in industrial and non-industrial domains.

- Describe end effectors, actuators (pneumatic, hydraulic, electric), and sensors (internal and external) along with their characteristics.
- Solve problems involving coordinate transformations, forward kinematics, and inverse kinematics of robotic manipulators.
- Interpret differential motion, dynamics modeling, and trajectory planning for robotic systems.
- Develop basic designs and evaluate performance of robotic systems based on actuation, sensing, and application requirements.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	Introduction to the role of a Robotics & Automation, what is and what is not a robot, Robot Anatomy, Classification of Robots, End effectors/Grippers and its design, programming, Industrial and Non-industrial applications of robots	8	-
2	Coordinate frames and transformations	6	4
3	Forward kinematics of manipulators, Inverse kinematics of manipulators	6	4
4	Differential motion, Dynamics modelling	6	4
5	Trajectory planning	6	2
6	Robot actuators and characteristics, Pneumatic, hydraulic and electric actuation systems	5	-
7	Robotic sensors and characteristics, Internal sensors, External sensors.	5	-
	Total	42	14

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- This course is essential in the era of Industry 4.0 and emerging Industry 5.0, where robotics and automation play a critical role in transforming manufacturing and service sectors. It provides fundamental knowledge of robot anatomy, kinematics, dynamics, actuators, and sensors, enabling learners to design and analyze modern robotic systems.
- The course supports applications in smart manufacturing, healthcare, autonomous systems, and human-robot collaboration, while also forming a strong foundation for integrating robotics with advanced technologies such as Artificial Intelligence, Machine Learning, and Computer Vision.
- It prepares students to meet current industrial demands and adapt to future developments in intelligent and autonomous robotic systems.

Text Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Robotics: Fundamental concepts and analysis **by A. Ghosal, Oxford university press**	2006
2	Robotics and Control **by R K Mittal & I J Nagrath, TMH**	2003
3	Industrial Robotics **by M P Groover,Pearson Edu**	2008

Reference Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Robotics: Control, sensing, vision and intelligence **by K Fu, R Gonzalez, and C S G Lee, McGraw Hill**	1987
2	Robotic Engineering **by Richard D. Klafter, Prentice Hall**	1989
3	Introduction to Robotics **by John J Craig, Pearson Edu. Prentice Hall**	2003

1.	**Course Title:**	Electro Pneumatics and Hydraulics
2.	**Subject Code:**	AR6L102
3.	**L-T-P-:**	3-0-0
4.	**Credit:**	3
5.	**Semester No:**	1
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	3
9.	**(Autumn/ Spring):**	Spring
10.	**Level:**	6
11.	**Pre- requisite subject(s):**	NA
12.	**Lab:**	NA
13.	**Instructor(s):**	Dr. Venugopal Arumuru

14. Syllabus:

Introduction to fluid power systems and safety practices in hydraulic and pneumatic systems. Fundamentals of fluid mechanics relevant to fluid power including pressure, flow, energy, and power transmission. Lumped parameter modelling of hydraulic and pneumatic actuators and basic dynamic behavior of fluid power components. Design methodology for fluid power systems including system layout, component selection, and performance considerations.

Basic concepts of pneumatics including air properties, compressed air generation, and system architecture. Components of pneumatic systems such as compressors, air preparation units, actuators, and control valves. Pneumatic actuators including cylinders and rotary actuators. Valves used in pneumatic systems including directional, flow control, and pressure control valves. Methods of speed control and flow regulation in pneumatic circuits. Pneumatic logic circuits including AND, OR, and NOT functions and their role in automation. Design and analysis of pneumatic circuits for industrial applications.

Basic concepts of hydraulics including hydraulic fluids, system characteristics, and power transmission. Components of hydraulic systems including pumps, valves, reservoirs, filters, and piping. Hydraulic actuators including hydraulic cylinders and motors. Hydraulic circuit

design and analysis for industrial applications. Types and working principles of hydraulic pumps. Maintenance aspects including troubleshooting, leakage testing, and preventive maintenance of fluid power systems.
Overview of simulation tools such as SimHydraulics (MATLAB) for modelling and analysis of fluid power systems.

15. Learning Outcomes:

- Explain and apply fundamental principles of fluid mechanics to analyze pressure, flow, energy, and power transmission in hydraulic and pneumatic systems.
- Design and analyze pneumatic and hydraulic circuits for industrial applications, selecting appropriate components such as compressors, actuators, valves, pumps, and filters.
- Implement and evaluate speed control, flow regulation, and logic functions (AND, OR, NOT) in pneumatic circuits, and perform circuit analysis for hydraulic actuators and motors.
- Simulate and troubleshoot fluid power systems using SimHydraulics (MATLAB), and carry out maintenance tasks including leakage testing and preventive maintenance.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial
1	**Introduction to Fluid Power Systems** Introduction to fluid power systems and safety practices Fundamentals of fluid mechanics — pressure, flow, energy, power transmission Lumped parameter modelling of hydraulic and pneumatic actuators Basic dynamic behavior of fluid power components Design methodology — system layout, component selection, performance considerations	6	0
2	**Pneumatic Systems** Air properties, compressed air generation, and system architecture Components — compressors, air preparation units, actuators, control valves Pneumatic actuators — cylinders and rotary actuators Valves — directional, flow control, and pressure control valves Speed control and flow regulation methods in pneumatic circuits	10	0

	Pneumatic logic circuits — AND, OR, NOT functions and automation Design and analysis of pneumatic circuits for industrial applications		
3	**Hydraulic Systems** Hydraulic fluids, system characteristics, and power transmission Components — pumps, valves, reservoirs, filters, and piping Hydraulic actuators — cylinders and motors Types and working principles of hydraulic pumps Hydraulic circuit design and analysis for industrial applications Maintenance — troubleshooting, leakage testing, and preventive maintenance	12	0
4	**Electro-Pneumatic and Electro-Hydraulic Systems** Introduction to electro-pneumatic and electro-hydraulic control Solenoid valves and electrically operated directional control valves Relay-based and PLC-based control of pneumatic and hydraulic circuits Proportional and servo valve control systems Integration of sensors and actuators for automated fluid power system	8	0
5	**Simulation and System Design** Overview of SimHydraulics (MATLAB/Simulink) for fluid power modelling Simulation of pneumatic and hydraulic circuits Performance analysis and system optimization using simulation tools Case studies — industrial fluid power system design	4	0
	Total	**42**	**0**

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- Industry 4.0 & Smart Manufacturing: Real-time sensing, data acquisition, and signal processing are core enablers of intelligent manufacturing, predictive maintenance, and cyber-physical systems demanding strong measurement fundamentals.
- IoT & Embedded Sensing: Rapid growth of IoT across healthcare, automotive, and infrastructure sectors requires engineers skilled in selecting and integrating diverse sensing elements with accurate, low-noise data acquisition pipelines.
- AI & Data-Driven Systems: The reliability of machine learning models, digital twins, and autonomous systems depends directly on measurement data quality making sound knowledge of sampling, quantisation, and noise management indispensable in an AI-driven technological landscape

18. Details of similar course/subject elsewhere, if any:

i.	**Name of the other IIT/ Universities offering the similar subjects:**	IIT ISM Dhanbad
ii.	**Course Name:**	Industrial Hydraulics and Automation
iii.	**L-T-P-:**	NPTEL
iv.	**Credit:**	

19. Newness of the course as compared to existing similar courses, if any (in 2-3 bullet points):

NA

20. Suggested Books:*

Text Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Pneumatic Systems: Principles and Maintenance, By S.R. Majumdar - Tata McGraw-Hill	2th Edition, 2010
2	Fluid Power with Applications by Anthony Esposito — Pearson Education	7th Edition, 2008

Reference Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Fundamentals of Fluid Power Control by John Watton - Cambridge University Press	7th Edition, , 2019
2	Hydraulic Control Systems by Herbert E. MerrittJohn-Wiley & Sons	1967

1.	**Course Title:**	Computer Aided Design & Manufacturing
2.	**Subject Code:**	AR6L103
3.	**L-T-P-:**	3-0-0
4.	**Credit:**	3
5.	**Semester No:**	1
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	3
9.	**(Autumn/ Spring):**	Autumn
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	None
12.	**Lab:**	None
13.	**Instructor(s):**	Dr. Gaurav Bartarya

14. Syllabus:

Computer Aided Design:

Overview of CAD, Software and hardware requirements of CAD, CAD applications, Solid modelling, wire frame modelling, B-rep, CSG approaches,

Plotting points & lines, Computer Graphics and its standards, Transformations and projections

Mathematical representation of curves and surfaces, Cubic, Bezier and B-spline curves and properties;

Computer Aided Manufacturing:

Introduction to NC, CNC, DNC, Machine axis system, CNC machine structure and hardware, Open and closed loop Control; Adaptive Control System-CNC and DNC.

NC part programming: word address format and APT.

Computer aided process planning and its types, Transfer lines, Group Technology, Flexible Manufacturing Systems, Types of Flexibility, work handling systems. AR/AS Systems, Manufacturing cell, CIM, Additive Manufacturing concept and methods.

Digital manufacturing: Role of Mechatronics and Robotics, case studies

15. Learning Outcomes:

- Studente will develop skills in parametric curve and surface modelling used in Computer Aided Design.
- Student will learn skills of manual and computer-aided part programming for CNC machine tools
- Student will develop understanding of flexible manufacturing systems and rapid prototyping techniques

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	Overview of CAD, Software and hardware requirements of CAD, CAD applications, Solid modelling, wire frame modelling, B-rep, CSG approaches, Transformations and projections, Plotting points & lines, Computer Graphics and its standards	8	-
2	Mathematical representation of curves and surfaces, Cubic, Bezier and B-spline curves and properties;	7	-
3	Introduction to NC, CNC, DNC, Machine axis system, CNC machine structure and hardware, Open and closed loop Control; Adaptive Control System-CNC and DNC.	5	-
4	NC part programming: Word address format and APT	6	-
5	Computer aided process planning and its types, Transfer lines, Group Technology, Flexible Manufacturing Systems, Types of Flexibility, work handling systems. AR/AS Systems, Manufacturing cell, CIM	10	-
6	Additive Manufacturing concept and methods. Digital manufacturing: role of Mechatronics and Robotics, case studies	6	-
	Total	42	-

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- Computer aided design and manufacturing is the back bone for cutting edge digital manufacturing for both subtractive and additivie routes of product design planning and fabrication.
- An understanding about the CAD basics, CNC machine hardware and CNC pogramming alongwith the knowledge of process planning is essential for optimized prduct design and manufacuturing leading to customized of mass scale product manufacturing as per requirement
- A roboust knowledge of the subject alongwith the application of the AI/ML and AR/VR technologies will lead to a highly efficient digital manufacturing system, which is a primary requirement for smart manufacturing.

Text Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Zeid I., *CAD / CAM Theory and Practice,* Tata McGraw – Hill.	2009
2	Groover, *Automation , Production systems & Computer integrated Manufacturing*, Pearson College Div.	2014
3	Rao P.N., Tewari N.K., Kundra T.K. *Computer aided Manufacturing,* Tata McGraw – Hill.	2017
4	Koren Y., *Computer Control of Manufacturing systems,* McGraw – Hill.	1984

Reference Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Rao P.N., *CAD/CAM principles and applications*, Tata McGraw – Hill.	2017
2	Amirouche F., *Principles of Computer Aided Design and Manufacturing*, Pearson Education.	2004
3	Seames W.S., *Computer Numerical Control Concepts and programming*, Delmar Cengage Learning	2001

SEMESTER - II (Theory Courses offered by IITBBS)

1.	Course Title:	Engineering Measurements
2.	**Subject Code:**	AR6L201
3.	**L-T-P-:**	3-1-0
4.	**Credit:**	4
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Elective
7.	**Contact Hours:**	52
8.	**Theory:**	4
9.	**(Autumn/ Spring):**	Spring
10.	**Level:**	6
11.	**Pre- requisite subject(s):**	NA
12.	**Lab:**	NA
13.	**Instructor(s):**	Dr. Venugopal Arumuru

14. Syllabus:

Principles of Measurement: Static characteristics and accuracy in the steady state, Generalized model, Measurement errors and error reduction techniques, Dynamic characteristics, Loading effects and noise, Transfer function, frequency responses, Dynamic errors and compensation, Random signals and effects of noise and interference, Noise sources and reduction methods, Economics of measurement systems: Reliability, Selection of measurement systems, Operating cost; Measurement System Design: Sensing elements: resistive, capacitive, inductive, electromagnetic and other sensing elements, Signal conditioning and processing elements, A/D conversion, sampling, quantization and encoding, Data Acquisition, Multiplexing, Data acquisition system, digital signal analysis; Specialized Measurement Systems: Principles of flow, optical and ultrasonic measurement systems, Heat transfer effects.

15. Learning Outcomes:

- Analyse and characterise measurement systems
- Design and select measurement system components
- Apply measurement principles to specialised engineering systems

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	**Principles of Measurement** • Static characteristics and accuracy in the steady state • Generalized measurement model • Measurement errors and error reduction techniques • Dynamic characteristics, Loading effects and noise • Transfer function and frequency responses • Dynamic errors and compensation	10	4
2	**Signals, Noise & System Reliability** • Random signals and effects of noise and interference • Noise sources and reduction methods • Economics of measurement systems: Reliability • Selection of measurement systems, Operating cost	8	2
3	**Measurement System Design — Sensing Elements** • Resistive, capacitive, inductive and electromagnetic sensing elements • Other sensing elements • Signal conditioning and processing elements	8	2
4	**Data Acquisition & Digital Signal Processing** • A/D conversion, sampling, quantization and encoding • Data Acquisition and Multiplexing • Data acquisition systems • Digital signal analysis	8	3
5	**Specialized Measurement Systems** • Principles of flow, Pressure and Temperature measurement systems • Optical measurement systems • Ultrasonic measurement systems • Heat transfer measurement effects and techniques	8	3
	Total	**42**	**14**

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- **Industry 4.0 & Smart Manufacturing:** Real-time sensing, data acquisition, and signal processing are core enablers of intelligent manufacturing, predictive maintenance, and cyber-physical systems demanding strong measurement fundamentals.
- **IoT & Embedded Sensing:** Rapid growth of IoT across healthcare, automotive, and infrastructure sectors requires engineers skilled in selecting and integrating diverse sensing elements with accurate, low-noise data acquisition pipelines.
- **Advanced Metrology & Precision Engineering:** Emerging fields such as nano-fabrication, biomedical devices, and aerospace systems demand expertise in dynamic error analysis, optical, ultrasonic, and thermal measurement techniques to meet increasingly stringent accuracy requirements.
- **AI & Data-Driven Systems:** The reliability of machine learning models, digital twins, and autonomous systems depends directly on measurement data quality making sound knowledge of sampling, quantisation, and noise management indispensable in an AI-driven technological landscape

18. Details of similar course/subject elsewhere, if any:

i.	**Name of the other IIT/ Universities offering the similar subjects:**	IIT Guwahati
ii.	**Course Name:**	Measurement and Instrumentation
iii.	**L-T-P-:**	3-0-0
iv.	**Credit:**	3

19. Newness of the course as compared to existing similar courses, if any (in 2-3 bullet points):

NA

20. Suggested Books:*

Text Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Measurement Systems: Application and Design — Ernest O. Doebelin (McGraw-Hill)	5th Edition, 2004
2	T.G. Beckwith, R.G. Marangoni & J.H. Lienhard, Mechanical Measurements, Pearson	6th Edition, 2006

Reference Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	R.S. Figliola & D.E. Beasley, Theory and Design for Mechanical Measurements, John Wiley & Sons	7th Edition, , 2019
2	Ernest O. Doebelin, Instrumentation Design Studies, CRC Press / Taylor & Francis,	2010

1.	**Course Title:**	Advanced Robotics
2.	**Subject Code:**	AR6L202
3.	**L-T-P-:**	3-1-0
4.	**Credit:**	4
5.	**Semester No:**	1
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	4
8.	**Theory:**	4
9.	**(Autumn/ Spring):**	Spring
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	Robotics
12.	**Lab:**	None
13.	**Instructor(s):**	Prof. V Pandu Ranga

14. Syllabus:

Control of manipulators, PID control of a single link manipulator, Robotic vision and image processing, Robot localization and mapping, Robot path planning algorithms, A*, Dijkstra, Rapidly exploring random trees (RRT), Probabilistic roadmap (PRM), Potential field method (PFM), SLAM working, advantages and future of localization and mapping, Human robot interaction, Human centred design in Robotics, Wheeled robots, Kinematics and dynamics of Legged robots, gait planning and control, Maintain Health, Safety and Environment at workplace, Robot Maintenance & Safety.

15. Learning Outcomes:

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

- Explain control strategies for manipulators, including PID control of single-link systems. Demonstrate knowledge of robotic vision, image processing, localization, mapping, and SLAM concepts.
- Compare and implement algorithms such as A*, Dijkstra, RRT, PRM, and Potential Field Method for robot navigation.

- Describe human-robot interaction, human-centered design, and the kinematics and dynamics of wheeled and legged robots.
- Apply principles of robot maintenance, workplace safety, and health, safety, and environmental (HSE) standards in robotic systems.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	Control of manipulators; PID control of a single-link manipulator; Robotic vision and image processing.	7	2
2	Robot localisation and mapping, Robot path planning algorithms, A*, Dijkstra, Rapidly exploring random trees (RRT), Probabilistic roadmap (PRM), Potential field method (PFM),	8	2
3	SLAM working, advantages and future of localisation and mapping.	6	2
4	Human Robot Interaction, Human-centred design in Robotics	7	2
5	Wheeled robots, Kinematics and dynamics of Legged robots, gait planning and control.	8	4
6	Maintain Health, Safety and Environment at the workplace, Robot Maintenance & Safety.	6	2
	Total	42	14

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- This course is essential for addressing the growing demand for intelligent and autonomous robotic systems in the era of Industry 4.0 and beyond. It equips learners with advanced knowledge of robot control, perception, and navigation through topics such as PID control, robotic vision, localization, SLAM, and path planning algorithms like A*, RRT, and PRM.
- These concepts are critical for modern applications including autonomous vehicles, mobile robots, drones, and smart logistics. The course also emphasizes human-robot interaction, human-centered design, and safety practices, ensuring effective and safe collaboration between humans and robots.
- Furthermore, it prepares students to contribute to future technologies such as service robotics, legged robots, and AI-driven autonomous systems, while maintaining high standards of maintenance, health, safety, and environmental responsibility.

Text Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Robotics and Control **by R K Mittal & I J Nagrath, TMH**	2003
2	Motion Planning for Humanoid Robots **by J K. Harada, E. Yoshida, K. Yokoi (Eds.), Springer**	2010
3	Modern Robotics by Vijay Kaushal, Khanna Publishing	

Reference Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Robot Motion Planning **by J C Latombe, Springer**	1991
2	Humanoid Robots Modeling and Control **by Dragomir N. Nenchev, Atsushi Konno, Butterworth Heinemann**	2019
3	Mobile Robotics a practical introduction **by Ulrich Nehmzow, Springer**	2012

1.	**Course Title:**	Robotic Vision and Artificial Intelligence
2.	**Subject Code:**	AR6L203
3.	**L-T-P-:**	3-1-0
4.	**Credit:**	4
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	4
8.	**Theory:**	4
9.	**(Autumn/ Spring):**	Spring
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	None
12.	**Lab:**	None
13.	**Instructor(s):**	Dr. Satish Kumar Panda

14. Syllabus:

Introduction to Python programming, Introduction to machine learning and artificial intelligence, Introduction to image processing, Machine learning for binary and multiclass classification, Matrices for quantifying accuracy, Data pre and post processing and database management, Explainable machine learning methods, Introduction to deep learning, Fundamentals of convolution and convolution layer, Deep learning methods for classification and segmentation, Network architecture optimization, Deep learning network training, testing and deployment, Graphical interface design for model deployment, Integration artificial intelligence with robotic vision, Object tracking using robotic vision

15. Learning Outcomes:

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

- Apply Python programming skills to develop basic to intermediate-level scripts for data handling, automation, and implementation of machine learning algorithms.

- Demonstrate understanding of machine learning and artificial intelligence concepts by designing models for binary and multiclass classification problems using appropriate algorithms.
- Perform image processing and data preprocessing techniques to prepare real-world datasets for analysis, including noise removal, normalization, and feature extraction.
- Evaluate model performance using appropriate metrics (such as accuracy, precision, recall, F1-score, and confusion matrix) and interpret results for informed decision-making.
- Develop and implement deep learning models (including convolutional neural networks) for image classification and segmentation tasks, and optimize network architectures for improved performance.
- Design and deploy AI-based applications by integrating graphical user interfaces, explainable AI techniques, and robotic vision systems for real-time object detection and tracking.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	Introduction to Python programming	3	1
2	Introduction to macine learning and artificial intelligence	3	1
3	Introduction to image processing	3	1
4	Machine learning for binary and multiclass classification	6	2
5	Data pre and post processing and database management	4	2
6	Explainable machine learning methods	3	1
7	Introductin to deep learning	6	1
8	Classical methods for image feature extraction	4	2
9	Neural networks training, testing and deployment	6	2
10	Deep learning network training, testing and deployment	4	1
	Total	42	14

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- Growing demand for AI and data-driven solutions: Industries such as healthcare, manufacturing, agriculture, and smart cities increasingly rely on machine learning and deep learning for automation, prediction, and decision-making.
- Rapid advancement in computer vision and robotics: With the rise of autonomous systems, surveillance, and medical imaging, skills in image processing, object tracking, and robotic vision are becoming essential.
- Integration of AI into real-world applications: There is a strong need for professionals who can not only build models but also deploy them through user interfaces and integrate them into practical systems.
- Emergence of explainable and ethical AI: As AI adoption expands, understanding model interpretability and transparency is crucial for trust, regulatory compliance, and responsible innovation.

Text Books:

Sl. No.	Name of the Book, Author & Publisher	Year of Publication / Reprint
1	Deep Learning, Goodfellow I.,Bengio Y. and Courville A.; MIT Press	2016
2	A Course in Machine Learning, Daumé, H. III, (freely available online).	2015
3	Digital Image processing, Gonzalez and Woods, 3rd edition, Pearson and Prentice Hall	2009
4	Neural Networks and Learning Machines, Simon H., Prentice Hall, Third Edition.	2008

SEMESTER – I (Laboratory Courses offered by SDI)

1.	**Course Title:**	Python Laboratory
2.	**Subject Code:**	AR6P101
3.	**L-T-P-:**	0-0-3
4.	**Credit:**	2
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	0
9.	**(Autumn/ Spring):**	Spring
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	None
12.	**Lab:**	None
13.	**Instructor(s):**	SDI/Dr. Satish Kumar Panda

14. Syllabus:

- Introduction: why Python
- Ecosystem: installation, workflow, data types, control flow, functions, scripts and modules, input, output, standard library, Numpy arrays, Pandas Basic, List Comprehensions, Multiple Function Arguments, Regular Expressions, Exception Handling, Sets, Serialization, Partial functions, Code Introspection, Closures, Decorators, Map, Filter, Reduce,
- Visualization with Matplotlib, Libraries for AI.
- Introduction to image processing
- Open CV library, Panda, Scipy, Sklearn

15. Learning Outcomes:

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

- Apply core Python programming concepts (functions, loops, and data structures) to solve computational and algorithmic problems efficiently.

- Implement data structures and algorithms (DSA) to optimize performance and handle real-world problem-solving scenarios.
- Utilize scientific computing libraries such as NumPy and Pandas for data manipulation, analysis, and preprocessing.
- Develop object-oriented programs to build modular, reusable, and scalable software solutions.
- Build and evaluate machine learning models using Scikit-learn, including dimensionality reduction techniques like PCA and clustering methods.
- Perform basic image processing tasks and develop simple graphical user interfaces (GUI) using Tkinter for interactive applications.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	Software installation and introduction to Python programming.	3	-
2	Familiarisation with Python syntax. Basic operations	3	-
3	If-else statement, looping	3	
4	Dictionary and Functions	3	-
5	Object-oriented programming, classes and inheritance	3	
6	Numpy and Matplotlib	3	-
7	Scipy, Sklearn, Panda libraray	3	
8	Clustering: K-means, PCA	3	-
9	Introduction to Tkinter	3	-
	Total	27	-

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- High demand for Python in data science and AI: Python has become the dominant language for machine learning, data analytics, and automation across industries.
- Growing importance of data-driven decision making: Skills in data handling (NumPy, Pandas) and machine learning are essential for extracting insights from large datasets.
- Integration of software development with AI applications: Combining DSA, OOP, and GUI development enables building complete, deployable intelligent systems.
- Emergence of interdisciplinary applications: Python is widely used in domains like healthcare imaging, finance, robotics, and scientific computing, making it a versatile future-ready skill.

1.	**Course Title:**	Industrial Robotics Laboratory
2.	**Subject Code:**	AR6P102
3.	**L-T-P-:**	0-0-3
4.	**Credit:**	2
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	0
9.	**(Autumn/ Spring):**	Autumn
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	None
12.	**Lab:**	None
13.	**Instructor(s):**	SDI Bhubaneswar/Prof. V Pandu Ranga

14. Syllabus:

Introduction to ABB Robot System, Demonstration on Flex Pendant & Manual Operation, Exercise on RAPID Programming Basics, Demonstration on Tool & Work Object Configuration, Exercise on Robot Motion & Path Control, Exercise on Pick and Place Application, Exercise on PLC Integration with ABB Robot, Exercise on Maintenance & Troubleshooting, Demonstration on Industrial Applications, Demonstration on Simulation using ABB RobotStudio.

15. Learning Outcomes:

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

- Identify the components, architecture, and working principles of ABB industrial robot systems..

- Demonstrate hands-on experience in manual operation using the Flex Pendant and develop basic programs using rapid prototyping.
- Develop the skillset related to setting up tool data and work object frames for accurate robot positioning and task execution.
- Analyze the robot motion control, path planning, and perform applications such as pick-and-place operations.
- Design the circuits related to PLC integration, perform basic troubleshooting and maintenance, and use ABB RobotStudio for simulation of industrial applications

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	Introduction to ABB Robot System 1.1 Familiarization with ABB robot components (Manipulator, IRC5 controller, FlexPendant) 1.2 Study of robot axes and configurations (6-axis robot) 1.3 Understanding coordinate systems (World, Base, Tool, WorkObject) 1.4 Power ON/OFF procedure and startup sequence	3	-
2	Demonstration on Flex Pendant & Manual Operation 2.1 Navigation of ABB FlexPendant interface 2.2 Manual jogging in Joint, Linear, and Reorientation modes 2.3 Setting tool and work object manually 2.4 Understanding speed override and safety modes	3	-
3	Exercise on RAPID Programming Basics 3.1 Introduction to RAPID programming language 3.2 Structure of RAPID program (Module, Procedure) 3.3 Basic instructions: MoveJ, MoveL, MoveC 3.4 Creating and saving programs	3	-
4	Demonstration on Tool & Work Object Configuration 4.1 Tool Center Point (TCP) calibration 4.2 Creating and defining WorkObjects (WObjData) 4.3 Load data configuration 4.4 Pick and place using defined TCP	3	-
5	Exercise on Robot Motion & Path Control 5.1 Speed settings 5.2 Zone data and path accuracy 5.3 Continuous vs fine motion 5.4 Path optimization	3	-
6	Exercise on Pick and Place Application 6.1 Programming pick and place cycle 6.2 Synchronizing gripper with motion	3	-

	6.3 Handling multiple objects 6.4 Basic palletizing		
7	Exercise on PLC Integration with ABB Robot 7.1 Interfacing ABB robot with PLC 7.2 Handshaking signals 7.3 Automatic cycle control 7.4 PLC-controlled pick and place	3	-
8	Exercise on Maintenance & Troubleshooting 8.1 Backup and restore of programs 8.2 System logs and fault diagnosis 8.3 Calibration checks 8.4 Common errors and solutions	3	
9	Demonstration on Industrial Applications 9.1 Palletizing routines 9.2 Welding simulation 9.3 Conveyor tracking 9.4 Offline programming	3	
10	Demonstration on Simulation using ABB RobotStudio 10.1 Introduction to RobotStudio 10.2 Creating virtual robot cell 10.3 Testing RAPID programs offline 10.4 Simulation and cycle time analysis	3	
	Total	30	-

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- Meets Industry Demand for Automation Skills: Provides hands-on experience with ABB robots, RAPID programming, and industrial applications essential for modern manufacturing and automation sectors.
- Supports Industry 4.0 and Smart Manufacturing**:** Covers PLC integration, motion control, and system configuration required for interconnected, flexible, and intelligent production systems.
- Prepares for Advanced Technologies: Introduces simulation using RobotStudio and concepts relevant to digital twins, AI-driven robotics, and virtual commissioning.
- Enhances Employability and Practical Competence**:** Develops skills in robot operation, maintenance, troubleshooting, and real-world applications, making students industry-ready.

1.	**Course Title:**	Electro Pneumatics and Hydraulics Lab
2.	**Subject Code:**	AR6P103
3.	**L-T-P-:**	0-0-3
4.	**Credit:**	2
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	0
9.	**(Autumn/ Spring):**	Autumn
10.	**Level:**	6
11.	**Pre- requisite subject(s):**	NA
12.	**Lab:**	NA
13.	**Instructor(s):**	SDI/Dr. Venugopal Arumuru

14. Syllabus:

Study of safety practices and identification of components in hydraulic and pneumatic systems. Measurement of pressure, flow, and speed in fluid power setups. Experimental study of pneumatic actuators and their performance characteristics. Study of different pneumatic valves and their operation. Development and testing of basic pneumatic circuits for actuator control. Implementation of speed control circuits using flow control valves. Design and testing of pneumatic logic circuits such as AND, OR, and NOT operations. Development of simple pneumatic automation circuits. Study of hydraulic system components including pumps, valves, cylinders, and reservoirs. Experimental investigation of hydraulic actuators and their characteristics. Development of basic hydraulic circuits for actuator control. Experimental study of hydraulic pump performance. Investigation of leakage detection and troubleshooting in fluid power systems. Preventive maintenance practices for hydraulic and pneumatic systems.

15. Learning Outcomes:

- Identify and measure components, pressure, flow, and speed in hydraulic and pneumatic systems following safe laboratory practices.
- Develop and test basic pneumatic and hydraulic circuits for actuator control, including speed control using flow control valves and logic circuits (AND, OR, NOT) for automation applications.
- Investigate and characterize the performance of pneumatic actuators, hydraulic actuators, and hydraulic pumps through experimental studies.
- Diagnose and perform leakage detection, troubleshooting, and preventive maintenance of fluid power systems.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Practical
1	**System Familiarization & Safety** Identification of components and safety practices in hydraulic and pneumatic systems Measurement of pressure, flow, and speed in fluid power setups	3	1
2	**Pneumatic Actuators & Valves** Experimental study of pneumatic actuators and their performance characteristics Study of different pneumatic valves and their operation	6	2
3	**Pneumatic Circuit Design** Development and testing of basic pneumatic circuits for actuator control using flow control valves, Design and testing of pneumatic logic circuits (AND, OR, NOT operations)	6	2
4	**Pneumatic Automation** Development of simple pneumatic automation circuits	3	1
5	**Hydraulic Systems & Actuators** Study of hydraulic system components (pumps, valves, cylinders, reservoirs)	6	2

	Experimental investigation of hydraulic actuators and development of basic hydraulic circuits for actuator control		
6	**Hydraulic Performance & Maintenance** Experimental study of hydraulic pump performance Investigation of leakage detection, troubleshooting, and preventive maintenance of fluid power systems	6	2
	Total	**30**	**10**

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- Robotic Actuation: Fluid power systems drive high-force robots, exoskeletons, and industrial manipulators.
- AI Maintenance: AI-based fault detection and sensor analytics enable self-diagnosing robotic systems.
- Soft Robotics: Pneumatic actuators are core to soft grippers, wearables, and safe human-robot interaction.

1.	**Course Title:**	CAD/CAM laboratory
2.	**Subject Code:**	AR6P104
3.	**L-T-P-:**	0-0-3
4.	**Credit:**	2
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	0
9.	**(Autumn/ Spring):**	Autumn
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	None
12.	**Lab:**	None
13.	**Instructor(s):**	SDI Bhubaneswar/Dr. Gaurav Bartarya

14. **Syllabus:**

Generation of various 3D models through protrusion, revolve and shell sweep. Feature based modeming like chamfer holes, fillet. Surface modelling like trimming, extending. Assembly of mechanical components through creation of constraints and mating conditions and motion analysis. Drafting of 3D models using any of the CAD modelling software. Generation of part programs on CNC for cylindrical and prismatic shaped components. Canned cycles, advance feature programming like pockets, threads. CNC program for Free form surface through CAM package.

15. **Learning Outcomes:**

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

- Prepare 3D models of mechanical components with various design features and assemble those components in a mechanical system and analyze the relative motions of the components.
- Study the component design and develop the CAM programs for their manufacturing on CNC machines

- Prepare the complex component designs with free form surfaces etc. and develop their CNC programs through CAM packages
- Develop the skillset of CAD and CAM technologies to prepare them for various roles in industry.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	1. Exercise On 3D Modeling (Solid Modeling) 1.1 Creation of 3D models using extrude, revolve 1.2 Sweep and loft operations 1.3 Boolean operations (union, subtract, intersect) 1.4 Feature-based modeling (holes, fillets, chamfers)	3	-
2	Exercise on Surface Modeling • Introduction to surface design • Creating basic surfaces • Surface trimming and extending • Conversion of surface to solid	3	-
3	Exercise on Assembly Modeling • Assembly creation using constraints • Mating conditions and degrees of freedom • Exploded views • Assembly motion study	3	-
4	Exercise on Drafting From 3D Models • Generation of 2D drawings from 3D models • Section views and detailed views • Bill of Materials (BOM) preparation • Tolerance and annotation	3	-
5	CAD Project • Complete product design (3D + Assembly) • Drawing documentation • Presentation and validation	3	-
6	Exercises on CNC Machine Operations – Turning 1.1 Introduction to CNC Lathe machine 1.2 Work holding devices and tooling 1.3 Tool geometry and offsets 1.4 Basic turning operations (Facing, Turning, Grooving, Threading)	3	-
7	Exercises on CNC Machine Operations – Milling • Introduction to CNC Milling machine • Types of milling cutters and tool holders	3	-

	• Workpiece setting and zero referencing • Basic milling operations (Face milling, Slotting, Pocketing, Drilling)		
8	Exercises on CNC Programming Fundamentals • Structure of CNC program • G-Codes and M-Codes • Tool compensation (G41, G42) • Canned cycles for drilling and turning • Subprograms and loops	3	
9	Exercises on Advanced CNC Programming • Multi-step machining operations • Thread cutting cycles • Contouring and profile machining • Optimization of machining time • Program editing and debugging	3	
10	Generation of part programs to produce free form and sculptured surfaces using CAM package	3	
	Total	30	-

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- Meets Industry Demand for computer aided design engineering skills
- Will develop a basis for developing design optimisation skills
- Understanding of the CAM programing will help students to develop and grow in the field digital manufacturing
- The lab will nurture the collaborative skills of the students to work on complex projects as a team.

SEMESTER – II (Laboratory Courses offered by SDI)

1.	**Course Title:**	Measurement and Instrumentation Laboratory
2.	**Subject Code:**	AR6P201
3.	**L-T-P-:**	0-0-3
4.	**Credit:**	3
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	0
9.	**(Autumn/ Spring):**	Spring
10.	**Level:**	6
11.	**Pre- requisite subject(s):**	NA
12.	**Lab:**	3
13.	**Instructor(s):**	Dr. Venugopal Arumuru

14. **Syllabus:**

Introduction to measurement systems and data acquisition using Arduino and Raspberry Pi. Interfacing of temperature sensors such as thermocouples, RTDs, and thermistors with microcontrollers and development of an IoT based temperature monitoring system. Measurement of pressure using Bourdon tube and piezoelectric pressure sensors and visualization of dynamic pressure signals using an oscilloscope. Flow measurement using differential pressure, thermal and ultrasonic flow sensors with real time monitoring using Arduino. Measurement of strain and force using strain gauges, load cells, and piezoelectric force sensors with signal conditioning and IoT based data logging. Measurement of linear and angular displacement using LVDTs and rotary encoders with Raspberry Pi based monitoring. Vibration measurement using accelerometers and analysis of vibration signals for rotating machinery monitoring. Measurement of torque and power using torque transducers and dynamometers. Development of IoT enabled measurement systems for temperature, pressure and flow monitoring. Use of oscilloscopes for signal troubleshooting and noise analysis in measurement systems. Implementation of non contact measurement

techniques using laser and ultrasonic sensors. Design and implementation of a complete IoT based mechanical measurement system

15. Learning Outcomes:

- Interface and configure sensors (temperature, pressure, flow, strain, displacement, vibration, torque) with Arduino and Raspberry Pi for real-time data acquisition and IoT-based monitoring systems.
- Measure and analyze physical quantities using appropriate instruments (oscilloscopes, strain gauges, LVDTs, accelerometers, dynamometers) with proper signal conditioning and data logging.
- Develop and implement complete IoT-enabled measurement systems integrating multiple sensor types for industrial parameters including temperature, pressure, and flow.
- Apply non-contact measurement techniques using laser and ultrasonic sensors, and evaluate signal quality through noise analysis and oscilloscope-based troubleshooting.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/	No. of Practical
1	**Principles of Measurement** • Calibration, Measurement errors • Dynamic characteristics • Transfer function and frequency responses • Dynamic errors and compensation	6	2
2	**Microcontroller** Measurement of strain and force using strain gauges, load cells, and piezoelectric force sensors	6	2
3	**Sensing Elements:** Resistive, capacitive, inductive and electromagnetic Signal conditioning and processing elements	6	2
4	**Data Acquisition & Digital Signal Processing** • A/D conversion, sampling, quantization and encoding • Data Acquisition, Digital signal analysis	3	2
5	**Specialized Measurement Systems:** Flow, Pressure and Temperature	3	3

	Total	**30**	**10**

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- **Industry 4.0 & Smart Manufacturing:** Real-time sensing, data acquisition, and signal processing are core enablers of intelligent manufacturing, predictive maintenance, and cyber-physical systems demanding strong measurement fundamentals.
- **IoT & Embedded Sensing:** Rapid growth of IoT across healthcare, automotive, and infrastructure sectors requires engineers skilled in selecting and integrating diverse sensing elements with accurate, low-noise data acquisition pipelines.
- **AI & Data-Driven Systems:** The reliability of machine learning models, digital twins, and autonomous systems depends directly on measurement data quality making sound knowledge of sampling, quantisation, and noise management indispensable in an AI-driven technological landscape

1.	**Course Title:**	Advanced Robotics Laboratory
2.	**Subject Code:**	AR6P202
3.	**L-T-P-:**	0-0-3
4.	**Credit:**	2
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	0
9.	**(Autumn/ Spring):**	Spring
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	None
12.	**Lab:**	None
13.	**Instructor(s):**	SDI Bhubaneswar/Prof. V Pandu Ranga

14. Syllabus:

Microcontroller programming for sensor and actuators**,** Wheeled robot path planning with LIDAR, Drone-based image processing and collection, Study of kinematics of snake-like robot, Object tracking using Stewart parallel manipulator, Motion planning of biped robot, SLAM (Simultaneous Localization and Mapping) using LiDAR in ROS 2, Pick and place operation using robotic arm and inverse kinematics, Gesture-controlled robot using accelerometer/IMU, Line following robot using IR sensors and PID control.

15. Learning Outcomes:

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

- Demonstrate the programing of microcontrollers to interface with sensors and actuators for real-time robotic applications.
- Use LiDAR, SLAM (ROS 2), and path planning techniques for autonomous navigation of wheeled robots.
- Analyze and implement kinematic models and motion planning for diverse robots such as snake-like, biped, and parallel manipulators.
- Develop drone-based image processing and object tracking systems.
- Design design and implement applications such as pick-and-place robots, gesture-controlled robots, and line-following robots using control algorithms like PID.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	Microcontroller programming for sensor and actuators. 1.1 Interfacing temperature and ultrasonic sensors with microcontroller 1.2 Controlling DC motor and servo motor using PWM.	3	-
2	Wheeled robot path planning with LIDAR. 2.1 Acquisition of LiDAR data and visualization. 2.2 Path planning using A* / Dijkstra algorithm	3	-
3	Drone-based image processing and collection. 3.1 Capturing aerial images using drone camera. 3.2 Image processing using OpenCV (edge detection/object detection).	3	-
4	Study of kinematics of snake-like robot. 4.1 Kinematic modelling of snake robot. 4.2 Locomotion control using wave-based motion	3	-
5	Object tracking using Stewart parallel manipulator. 5.1Forward and inverse kinematics of Stewart platform. 5.2 Object tracking using vision feedback control.	3	-
6	Motion planning of biped robot. 6.1 Gait generation for walking robot. 6.2 Stability analysis using Zero Moment Point (ZMP).	3	-
7	SLAM (Simultaneous Localization and Mapping) using LiDAR in ROS 2. 7.1 Running LiDAR driver and publishing scan data. 7.2 Implementing SLAM using ROS 2 (e.g., slam toolbox).	3	-
8	Pick and place operation using robotic arm and inverse kinematics.	3	

	8.1 Forward and inverse kinematics of robotic arm. 8.2 Pick and place operation using trajectory planning.		
9	Gesture-controlled robot using accelerometer/IMU. 9.1 Reading accelerometer and gyroscope data. 9.2 Mapping gestures to robot movement.	3	
10	Line following robot using IR sensors and PID control. 10.1Interfacing IR sensors and reading values. 10.2Implementing PID control for smooth line following.	3	
	Total	30	-

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- Foundation for Intelligent and Autonomous Systems: Builds core skills in microcontroller programming, sensor integration, and control (PID), which are essential for developing modern autonomous robots and embedded systems.
- Alignment with AI, Robotics, and Industry 4.0 Trends: Covers advanced topics like SLAM (ROS 2), LiDAR-based navigation, and path planning that are widely used in self-driving vehicles, smart factories, and service robotics.
- Supports Emerging Technologies in Drones and Computer Vision**:** Prepares students for applications in drone-based imaging, surveillance, mapping, and vision-driven object tracking used in defense, agriculture, and logistics.
- Enhances Capability in Advanced Robotic Design and Applications: Develops understanding of kinematics, inverse kinematics, and motion planning for complex robots (biped, snake, parallel manipulators), enabling innovation in next-generation robotics.

1.	**Course Title:**	Robotic Vision Laboratory
2.	**Subject Code:**	AR6P203
3.	**L-T-P-:**	0-0-3
4.	**Credit:**	2
5.	**Semester No:**	2
6.	**Core/Elective/Breadth:**	Core
7.	**Contact Hours:**	3
8.	**Theory:**	0
9.	**(Autumn/ Spring):**	Spring
10.	**Level:**	6 level
11.	**Pre- requisite subject(s):**	None
12.	**Lab:**	None
13.	**Instructor(s):**	SDI/Dr. Satish Kumar Panda

14. Syllabus:

Design and development of robotic vision system for object detection, Design and development of robotic vision system for object tracking, Design and development of control and vision system for drones and underwater rovers, Drone-based object detection and identification, Virtual reality for robotic vision, LIDAR sensor data processing and decision making, Digital image correlation and image processing, Machine health monitoring using vision and acoustic, Autonomous robot navigation and path planning.

15. Learning Outcomes:

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

- Design and implement robotic vision systems for real-time object detection and tracking using cameras and vision algorithms.
- Develop and integrate vision-based control systems for autonomous platforms such as drones and underwater rovers.

- Apply advanced sensing techniques (e.g., LiDAR, imaging, and acoustic signals) for environment perception, decision-making, and machine health monitoring.
- Perform image processing and digital image correlation to extract meaningful features for motion analysis, deformation tracking, and industrial inspection.
- Build autonomous navigation and path planning systems by combining sensor data with intelligent algorithms for real-world robotic applications.
- Utilize emerging technologies such as virtual reality and simulation tools to design, test, and optimize robotic vision systems in controlled environments.

16. Module-wise break up of topics:

Sl. No.	Course Contents	Contact Hours/ No. of Lectures	No. of Tutorial / Practical
1	Design and development of robotic vision system for object detection	3	-
2	Design and development of robotic vision system for object tracking	3	-
3	Design and development of control and vision system for drones and underwater rovers	3	-
4	Drone-based object detection and identification	3	-
5	Virtual reality for robotic vision	3	-
6	LIDAR sensor data processing and decision making	3	-
7	Digital image correlation and image processing	3	-
8	Machine health monitoring using vision and acoustic	3	
9	Autonomous robot navigation and path planning	3	
	Total	27	-

17. Need of the course in terms of current & future trends in technology & science (3-4 bullet points)

- Rapid growth of autonomous and intelligent systems: Industries are increasingly adopting drones, autonomous vehicles, and underwater robots, creating demand for skills in robotic vision, navigation, and control systems.
- Advancements in multi-sensor perception technologies: Integration of cameras, LiDAR, and acoustic sensing is becoming essential for accurate environment understanding and real-time decision-making.
- Industry 4.0 and smart monitoring systems: Vision-based inspection, machine health monitoring, and predictive maintenance are transforming manufacturing and infrastructure management.
- Emergence of immersive and simulation technologies: Virtual reality and digital twins are enabling efficient design, testing, and optimization of robotic systems before real-world deployment.