ANNEXURE

M. Tech Programme in Robotics and Artificial Intelligence

Programme Highlights

Program name: **M. Tech in Robotics and Artificial Intelligence**

Department/Center: Center for Intelligent Cyber-Physical Systems (CICPS)

Eligibility: **Regular (BTech (Equivalent) in EE/EEE/CSE/Mech/PE/Civil/IT/Design and GATE EE/ECE/ME/CSE/CE/PE) or CEED.**
Sponsored (Industry), GATE not mandatory, written test and/or interview

Intake: **40, 10 (MHRD) + 10 (TIH at IITG) + 20 Sponsored (Industry)**

Goals and career prospects

The world is undergoing a Cyber-Physical Systems revolution with Robotics being an integral part of it. The Government of India has already committed Rupees 3660 crores to setup Technology Innovation Hubs and Sectoral Application Hubs as part of the National Mission for Interdisciplinary Cyber-Physical Systems (NM-ICPS). The development of Robotic Systems is an important step to keep pace with the development in the theme of Cyber-Physical Systems. Robotics is a blend of engineering and science that includes mechanical engineering, electrical engineering and computer science and programming. The robotics sector is constantly expanding and can lead to potential career opportunities in agriculture, transportation, environment, defence, industry, manufacturing, medicine, space and underwater exploration and service. The new study program initiated by the Center for Intelligent Cyber-Physical Systems (CICPS) is designed to address these future topics and help to meet the growing need for engineers. Graduates will be able to use scientific methods and analyses for solving complex problems in both practice and research. The program offers several optional modules in the field of Robotics and Artificial Intelligence. In addition to compulsory modules based on mathematical and technical principles as well as interdisciplinary qualifications, application-specific expertise is conveyed in elective modules on different topics.

Semester 1	**Semester 2**
RA501: Fundamentals of Robotics (3-0-0-6)	RA505: Robot Sensing and Vision (3-0-0-6)
RA502: Artificial Intelligence (2-0-2-6)	RA506: Machine Learning (3-0-0-6)
RA503: Robot Design Laboratory (0-0-3-3)	xxxxx: Elective 3
RA504: Programming Laboratory (0-0-3-3)	xxxxx: Elective 4
xxxxx: Elective 1*	xxxxx: Elective 5
xxxxx: Elective 2	
Semester 3	**Semester 4**
RA507: Technical Writing (1-0-2-4)	RA599: Project Phase-II (0-0-24-24)
RA598: Project Phase-I (0-0-20-20)	

*Elective 1 must be taken only from the following list – ME501 (Advanced Engineering Mathematics), EE590 (Linear Algebra and Optimization), EE591 (Probability and Stochastic Processes), EE 655 (Mathematical Techniques for Control and Signal Processing), MA589 (Statistical Foundations for Data Science), CS514 (Mathematics for Computer Science),

- All the electives offered will be of 6 credits, i.e., (3-0-0-6/2-0-2-6) or higher
- It is proposed to have the course code RA.

Semester wise breakup

Semester 1

Fundamentals of Robotics: RA501 (3-0-0-6)

The course will cover:

- Introduction to Robotics: Types and Classification of robots; Science and Technology of Robots
- Rigid Body Transformation: Overview of Rigid Body Kinematics; Homogeneous Transformation; Link Transformation Matrices
- Forward and Inverse Kinematics & Dynamics of Robots
- Planning and Control of Robots

Textbooks

1) Fu. K.S., Gonzalez R.C. and Lee C.S.G., *Robotics: Control, Sensing, Vision and Intelligence*, Tata McGraw Hill, 2008.
2) Ghosal A. Robotics: *Fundamental Concepts and Analysis*, Oxford University Press, 2006.
3) Craig J.J., *Introduction to Robotics – Mechanics and Control*, Pearson Prentice Hall, 2005.
4) Murray, Li and Sastry, A Mathematical Introduction to Robot Manipulation, CRC Press, 1994.

References:

1) Spong M.W., Hutchinson S. and Vidyasagar M., *Robot Modeling and Control*, John Wiley Sons & Inc., 2005.
2) Saha. S.K., *Introduction to Robotics*, McGraw Hill Education (India) Private Limited, 2014.

Artificial Intelligence: RA502 (2-0-2-6)

- Introduction;
- Searching Techniques: uninformed search strategies, informed (heuristic) search strategies, local search algorithms, searching in non-deterministic and partially observable environment, adversarial search,
- Temporal Probability models and inference in temporal models: filtering, prediction, smoothing, most likely explanation, Dynamic Bayesian Networks, Hidden Markov Model, Kalman Filter, Extended Kalman Filter, Particle Filter, Learning Probabilistic Models;
- Decision making: Markov Decision Processes (MDPs), Partially Observable MDPs (POMDPs);
- Learning: Introduction to supervised learning, unsupervised learning, and reinforcement learning

Textbooks

1) Stuart Russell and Peter Norvig, Artificial Intelligence A Modern Approach, 3rd Edition, Pearson, 2014.

References

1) Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
2) C. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
3) R.S. Sutton and A.G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, MIT Press, 2018.

Robot Design Laboratory: RA503 (0-0-3-3)

- Demonstrations on Robot Mechanisms and their design,
- Studies on Existing Robots, Computer-Aided-Design of Robots,
- Robot Hardware and Control System Design
- ROS
- Topics in Machine Elements.

Textbooks

1) Sandor G.N. and Erdman A.G., Advanced Mechanism Design: Analysis and Synthesis, Vol. 2, Prentice Hall, New Jersey, 1984.
2) Zeid, Ibrahim. CAD/CAM theory and practice. McGraw-Hill Higher Education, 1991.
3) Rivin E.I., Mechanical Design of Robots, McGraw Hill, New York, 1988.
4) D.J. Bell, P.A. Cook, N. Munro, Design of Modern Control Systems, IEE Control Engineering Series, Institution of Engineering and Technology, 1982.

References

1) G. Budynas and J. K. Nisbett, Shigley's Mechanical Engineering Design, 10th Edition, McGraw Hill, 2015.
2) Joseph L., Mastering ROS for Robotics Programming, Packt Publishing, Birmingham, 2015.
3) Nnaji B.O., Computer-aided Design, Selection and Evaluation of Robots, Manufacturing Research & Technology, Elsevier Science Ltd, 1986.

Programming Laboratory: RA504 (0-0-3-3)

- Introduction: why Python
- ecosystem: installation, workflow, data types, control flow, functions, scripts and modules, input, output, standard library, Numpy arrays, Pandas Basic, Generators ,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.

Textbooks/References

- Python Data Science Handbook, O'REILLY https://jakevdp.github.io/PythonDataScienceHandbook/

Robot Sensing and Vision: RA505 (3-0-0-6)

- Robotic vision sensors and their interfacing
- Fundamentals of Computer Vision: Image accusation and representation, image transformation, filtering, restoration, morphing, Camera Models, Calibration, Single view geometry, Multiple view geometry, Epipolar geometry, RANSAC
- Position and Orientation: Feature based alignment; Pose estimation; Time varying pose and trajectories, Structure from motion, dense Motion Estimation, Visual Odometry (Semi-direct VO, direct sparse odometry), Bundle Assignment
- Localization and Mapping: Initialization, Tracking, Mapping, geometric SLAM formulations (indirect vs. direct error formulation, geometry parameterization, sparse vs. dense model, optimization approach), Relocalization and map Optimization, Visual SLAM, Examples: Indirect (Feature based) methods (MonoSLAM, PTAM, ORB-SLAM), Direct methods (DTAM, LSD-SLAM), Sensor combinations (IMU, mono vs. Stereo, RGB-Depth), Analysis and parameter studies.
- Recognition and Interpretations: Concepts of machine learning and deep learning, sequence modeling, Learning for robotic vision: Active learning, incremental and class incremental learning identify unknowns, uncertainty estimation, Embodiment for robotic vision: active vision, spatial and temporal embodiment, reasoning for object, scene and scene semantics.

Text Books:

- H. R. Everett, Sensors for Mobile Robots: Theory and Application, A K Peters/CRC Press, 1995.
- Dahiya, Ravinder S., Valle, Maurizio, Robotic Tactile Sensing, Springer, 2013.
- S. R. Deb, Sankha Deb, Robotics Technology and Flexible Automation, 2nd edition, McGraw Hill Education, 2017.
- Milan Sonka, Vaclav Hlavac and Roger Boyle, Image Processing, Analysis and Machine Vision, Cengage, Third Edition (2013)

- Abdessalan Bouzerdoum, George Mamic and M. Bennamoun, Object Recognition:Fundamentals & Case Studies, First Edition, Universities Press, 2008.
- Abdulmajeed Wael, Mansoor Revan, Visual Robot Slam of 2D & 3D Indoor Environment, LAP Lambert Academic Publishing, 2014.

References

- Buduma N., Fundamentals of Deep Learning, Designing Next-Generation Artificial Intelligence Algorithms ,O'Reilly Media, June 2015
- D. A. Forsyth and J. Ponce, Computer Vision, A Modern Approach, Pearson Education, 2003.
- D. H. Ballard and C. M. Brown, Computer Vision, Prentice Hall, 1982.

Machine Learning: RA506 (3-0-0-6)

- Introduction to supervised and unsupervised learning frameworks;
- Dimensionality reduction: Feature selection; PCA;
- Supervised learning: Bayesian classification, Perceptrons, Multi-layer perceptron, RBF Networks, Decision Trees, Support Vector Machines, Convolutional Neural Networks, Recurrent Neural Networks;
- Unsupervised learning: K-Means clustering, DBSCAN, Non-parametric Estimation, Mean-shift clustering; Classification performance analysis; Ensemble methods – Boosting and Bagging;
- Applications and Case Studies in Robotics.

Textbooks:

1. E. Alpaydin, Introduction to Machine Learning, 3rd Edition, Prentice Hall (India) 2015.
2. R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, 2nd Edn., Wiley India, 2007.
3. C. M. Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer, 2006.
4. S. O. Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson Education (India), 2016
5. I. Goodfellow, Y. Bengio , A. Courville, Deep Learning, MIT Press, 2017

Technical Writing: RA507 (1-0-2-4)

- Modes of technical communication: Reports, Technical papers, book chapters, Manuals, Posters.
- Structure of a technical document.
- Copyright issues in technical writing: existing laws, open sources, permission procedure.

- How to write a good technical paper?, Proper procedure in citing already published works, Referencing styles.
- Common mistakes of English in scientific documents.
- Proper way of writing and citing equations. Proper use of figures and tables. Writing a good review paper.
- Writing of abstract, synopsis, cover letters, responses, discussion and keywords

References

1. Alred, G. J., Brusaw, C. T., & Oliu, W. E. Handbook of technical writing. 9th edition. Bedford/St. Martin, 2009
2. Parija, S.C. & Kate, V. (Ed.), Writing and publishing a scientific research paper, Springer/Singapore, 2017

Electives

ME531 Mechanical Vibration

ME542 Numerical Analysis

ME628 Additive manufacturing technologies

ME532 Finite Element Methods in Engineering

ME629 Design of Mechatronic Products

ME674 Soft Computing in Engineering

ME608 CAD CAM

ME615 Rotor Dynamics

ME543 Computational Fluid Dynamics

ME645 Mechatronics

ME609 Optimization Methods in Engineering

ME644 Modern Control

CS551 Wireless Networks

CS590 Deep Learning

CS666 Mobile Robotics

CS571 Human Computer Interaction

CS530 Machine Learning using Cloud Computing

CS565 Intelligent Systems And Interfaces

CS566 Speech Processing

CS578 Internet of Things

EE523 Introduction to Machine Learning

EE535 Advanced Topics in Machine Learning

EE646 Optical Measurement Techniques and Applications

EE550 Linear Systems Theory

EE551 Estimation and Identification

EE659 Fuzzy Logic and Neural Networks

EE626 Pattern Recognition and Machine Learning

EE660 Modeling and Control of Power Electronic Converters

EE656 Robust Control

EE657 Intelligent Sensors and Actuator

EE553 Optimal Control

EE554 Nonlinear Systems and Control

EE653 (Modeling and Simulation of Dynamic Systems),

EE 694 (Introduction to Parallel Computing)

DD 533 (Auditory and Voice Interaction Design)

DD 509 (Interaction Design)

DD 516 (Digital Human Modelling and Simulation in Product Design)

DD518 (Representation Techniques for Animation)

Proposal for a New Course / Revision of a Course

Course Number & Title: **RA501**, **Fundamentals of Robotics**	
L-T-P-C: **3-0-0-6**	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**	
Kind of Proposal (New Course / Revision of Existing Course): **New Course**	
Offered as (Compulsory / Elective): **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered to: **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered in (Odd/ Even / Any): **Odd**	
Offered by (Name of Department/ Center): **Centre for Intelligent Cyber-Physical Systems (CICPS)**	
Pre-Requisite: None	
Preamble / Objectives (Optional): This course will serve as an introductory robotics course for the design of control of complex robotic systems	
Course Content/ Syllabus: Introduction to Robotics: Types and Classification of robots; Science and Technology of Robots, Rigid Body Transformation: Overview of Rigid Body Kinematics; Homogeneous Transformation; Link Transformation Matrices, Forward and Inverse Kinematics & Dynamics of Robots, Planning and Control of Robots	
Text Books: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1.	Fu. K.S., Gonzalez R.C. and Lee C.S.G., *Robotics: Control, Sensing, Vision and Intelligence*, Tata McGraw Hill, 2008.
2.	Ghosal A., *Robotics: Fundamental Concepts and Analysis*, Oxford University Press, 2006.
3.	Craig J.J., *Introduction to Robotics – Mechanics and Control*, Pearson Prentice Hall, 2005.
4.	Murray, Li and Sastry, *A Mathematical Introduction to Robot Manipulation*, CRC Press, 1994.
References	
1.	Spong M.W., Hutchinson S. and Vidyasagar M., *Robot Modeling and Control*, John Wiley Sons & Inc., 2005.
2.	Saha. S.K., *Introduction to Robotics*, McGraw Hill Education (India) Private Limited, 2014.

Course Number & Title: **RA502, Artificial Intelligence**	
L-T-P-C: **2-0-2-6**	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**	
Kind of Proposal (New Course / Revision of Existing Course): **New Course**	
Offered as (Compulsory / Elective): **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered to: **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered in (Odd/ Even / Any): **Odd**	
Offered by (Name of Department/ Center): **Centre for Intelligent Cyber-Physical Systems (CICPS)**	
Pre-Requisite: None	
Preamble / Objectives (Optional): This course will introduce selected topics in Artificial Intelligence (AI) with a focus on Robotics. The LAB component will allow the students to apply these AI- techniques to the problems relevant to robotics such as Path Planning, Localization and Mapping, and Motion Planning.	
Course Content/ Syllabus : Introduction ; Searching Techniques: uninformed search strategies, informed (heuristic) search strategies, local search algorithms, searching in non-deterministic and partially observable environment, adversarial search, Temporal Probability models and inference in temporal models: filtering, prediction, smoothing, most likely explanation, Dynamic Bayesian Networks, Hidden Markov Model, Kalman Filter, Extended Kalman Filter, Particle Filter, Learning Probabilistic Models; Decision making: Markov Decision Processes (MDPs), Partially Observable MDPs (POMDPs); Learning: Introduction to supervised learning, unsupervised learning, and reinforcement learning	
Text Books: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1.	Stuart Russell and Peter Norvig, *Artificial Intelligence A Modern Approach*, 3rd Edition, Pearson, 2014
References	
1.	Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
2.	C. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
3.	R.S. Sutton and A.G. Barto, *Reinforcement Learning: An Introduction*, 2nd Edition, MIT Press, 2018

Course Number & Title: **RA503, Robot Design Laboratory**	
L-T-P-C: **0-0-3-3**	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**	
Kind of Proposal (New Course / Revision of Existing Course): **New Course**	
Offered as (Compulsory / Elective): **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered to: **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered in (Odd/ Even / Any): **Odd**	
Offered by (Name of Department/ Center): **Centre for Intelligent Cyber-Physical Systems (CICPS)**	
Pre-Requisite: None	
Preamble / Objectives (Optional): This course covers the design of robotic systems. This course will provide a hands-on approach to the design and development of robots by first providing the students with required fundamentals. It will enable the student to understand and work with robot hardware and software.	
Course Content/ Syllabus : Demonstrations on Robot Mechanisms and their design; Studies on Existing Robots, Computer-Aided-Design of Robots; Robot Hardware and Control System Design; ROS; Topics in Machine Elements.	
Text Books: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1.	Sandor G.N. and Erdman A.G., *Advanced Mechanism Design: Analysis and Synthesis*, Vol. 2, Prentice Hall, New Jersey, 1984.
2.	Zeid, Ibrahim. CAD/CAM theory and practice. McGraw-Hill Higher Education, 1991.
3.	Rivin E.I., *Mechanical Design of Robots*, McGraw Hill, New York, 1988.
4.	D.J. Bell, P.A. Cook, N. Munro, *Design of Modern Control Systems*, IEE Control Engineering Series, Institution of Engineering and Technology, 1982.
References	
1.	G. Budynas and J. K. Nisbett, *Shigley's Mechanical Engineering Design*, 10th Edition, McGraw Hill, 2015.
2.	Joseph L., *Mastering ROS for Robotics Programming*, Packt Publishing, Birmingham, 2015.
3.	Nnaji B.O., *Computer-aided Design, Selection and Evaluation of Robots*, Manufacturing Research & Technology, Elsevier Science Ltd, 1986.

Course Number & Title: **RA504, Programming Laboratory**	
L-T-P-C: **0-0-3-3**	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**	
Kind of Proposal (New Course / Revision of Existing Course): **New Course**	
Offered as (Compulsory / Elective): **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered to: **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered in (Odd/ Even / Any): **Odd**	
Offered by (Name of Department/ Center): **Centre for Intelligent Cyber-Physical Systems (CICPS)**	
Pre-Requisite: NIL	
Preamble: An efficient programming language for implementing different aspects for artificial intelligence and machine learning is a primary necessity. To this end, **Python** is one of the popular and emerging high-level language where different aspect of AI/ML related programming can easily be realized. In recent time, a comprehensive set of libraries are available for Python in the AI/ML domain.	
Syllabus: Introduction: why Python, ecosystem: installation, workflow, data types, control flow, functions, scripts and modules, input, output, standard library, Numpy arrays, Pandas Basic, Generators ,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.	
Books	
Textbooks/References:	
1.	Python Data Science Handbook, O'REILLY https://jakevdp.github.io/PythonDataScienceHandbook/
2.	
3.	

Course Number & Title: **RA505, Robot Sensing and Vision**	
L-T-P-C: **3-0-0-6**	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**	
Kind of Proposal (New Course / Revision of Existing Course): **New Course**	
Offered as (Compulsory / Elective): **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered to: **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered in (Odd/ Even / Any): **Odd**	
Offered by (Name of Department/ Center): **Centre for Intelligent Cyber-Physical Systems (CICPS)**	
Pre-Requisite: None	
Preamble / Objectives (Optional): None	
Course Content/ Syllabus : Robotic vision sensors and their interfacing; Fundamentals of Computer Vision: Image accusation and representation, image transformation, filtering, restoration, morphing, Camera Models, Calibration, Single view geometry, Multiple view geometry, Epipolar geometry, RANSAC; Position and Orientation: Feature based alignment; Pose estimation; Time varying pose and trajectories, Structure from motion, dense Motion Estimation, Visual Odometry (Semi-direct VO, direct sparse odometry), Bundle Assignment; Localization and Mapping: Initialization, Tracking, Mapping, geometric SLAM formulations (indirect vs. direct error formulation, geometry parameterization, sparse vs. dense model, optimization approach), Relocalization and map Optimization, Visual SLAM, Examples: Indirect (Feature based) methods (MonoSLAM, PTAM, ORB-SLAM), Direct methods (DTAM, LSD-SLAM), Sensor combinations (IMU, mono vs. Stereo, RGB-Depth), Analysis and parameter studies; Recognition and Interpretations: Concepts of machine learning and deep learning, sequence modeling, Learning for robotic vision: Active learning, incremental and class incremental learning identify unknowns, uncertainty estimation, Embodiment for robotic vision: active vision, spatial and temporal embodiment, reasoning for object, scene and scene semantics.	
Text Books: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1.	H. R. Everett, *Sensors for Mobile Robots: Theory and Application*, A K Peters/CRC Press, 1995.
2.	Dahiya, Ravinder S., Valle, Maurizio, *Robotic Tactile Sensing*, Springer, 2013.
3.	S. R. Deb, Sankha Deb, *Robotics Technology and Flexible Automation*, 2nd edition, McGraw Hill Education, 2017.
4.	Milan Sonka, Vaclav Hlavac and Roger Boyle, *Image Processing, Analysis and Machine Vision*, Cengage, Third Edition (2013)
5.	Abdessalan Bouzerdoum, George Mamic and M. Bennamoun, *Object Recognition:Fundamentals & Case Studies*, First Edition, Universities Press, 2008.
6.	Abdulmajeed Wael, Mansoor Revan, *Visual Robot Slam of 2D & 3D Indoor Environment*, LAP Lambert Academic Publishing, 2014.
References	
1.	Buduma N., *Fundamentals of Deep Learning, Designing Next-Generation Artificial Intelligence Algorithms* ,O'Reilly Media, June 2015
2.	D. A. Forsyth and J. Ponce, *Computer Vision, A Modern Approach*, Pearson Education, 2003.
3.	D. H. Ballard and C. M. Brown, *Computer Vision*, Prentice Hall, 1982.

Course Number & Title: **RA506, Machine Learning**	
L-T-P-C: **3-0-0-6**	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**	
Kind of Proposal (New Course / Revision of Existing Course): **New Course**	
Offered as (Compulsory / Elective): **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered to: **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered in (Odd/ Even / Any): **Odd**	
Offered by (Name of Department/ Center): **Centre for Intelligent Cyber-Physical Systems (CICPS)**	
Pre-Requisite: None	
Preamble / Objectives (Optional): None	
Course Content/ Syllabus : Introduction to supervised and unsupervised learning frameworks; Dimensionality reduction: Feature selection; PCA; Supervised learning: Bayesian classification, Perceptrons, Multi-layer perceptron, RBF Networks, Decision Trees, Support Vector Machines, Convolutional Neural Networks, Recurrent Neural Networks; Unsupervised learning: K-Means clustering, DBSCAN, Non-parametric Estimation, Mean-shift clustering; Classification performance analysis; Ensemble methods - Boosting and Bagging; Applications and Case Studies in Robotics.	
Text Books: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1.	E. Alpaydin, Introduction to Machine Learning, 3rd Edition, Prentice Hall (India) 2015.
2.	R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, 2nd Edn., Wiley India, 2007.
3.	C. M. Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer, 2006.
4.	S. O. Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson Education (India), 2016
5.	I. Goodfellow, Y. Bengio , A. Courville, Deep Learning, MIT Press, 2017
References	

Course Number & Title: **RA507, Technical Writing**	
L-T-P-C: **1-0-2-4**	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**	
Kind of Proposal (New Course / Revision of Existing Course): **New Course**	
Offered as (Compulsory / Elective): **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered to: **Core for M. Tech in Robotics and Artificial Intelligence**	
Offered in (Odd/ Even / Any): **Odd**	
Offered by (Name of Department/ Center): **Centre for Intelligent Cyber-Physical Systems (CICPS)**	
Pre-Requisite: None	
Preamble / Objectives (Optional): None	
Course Content/ Syllabus : Modes of technical communication: Reports, Technical papers, book chapters, Manuals, Posters. Structure of a technical document. Copyright issues in technical writing: existing laws, open sources, permission procedure. How to write a good technical paper?, Proper procedure in citing already published works, Referencing styles. Common mistakes of English in scientific documents. Proper way of writing and citing equations. Proper use of figures and tables. Writing a good review paper. Writing of abstract, synopsis, cover letters, responses, discussion and keywords	
Text Books/References:	
1.	Alred, G. J., Brusaw, C. T., & Oliu, W. E. Handbook of technical writing. 9th edition. Bedford/St. Martin, 2009
2.	Parija, S.C. & Kate, V. (Ed.), Writing and publishing a scientific research paper, Springer/Singapore, 2017