MANIPAL UNIVERSITY
JAIPUR
(University under Section 2(f) of the UGC Act)

Faculty of Science, Technology and Architecture, School of Engineering
Department of Mechatronics Engineering
Degree: Bachelor of Technology in Robotics and Artificial intelligence Total Credit: 160
Scheme

	Third Semester						**Fourth Semester**				
Code	Subject Name	L	T	P	C	Code	Subject Name	L	T	P	C
MEE2001	Engineering Economics	3	0	0	3	MAS21XX MEE22XX	Statistics & Probability	3	0	0	3
MBB2101	Management of Technology	3	0	0	3	RAI2201	Sensors and Control System	3	1	0	4
RAI2101	Embedded Controllers	3	1	0	4	RAI2202	Robot Kinematics and Dynamics	3	1	0	4
RAI2102	Basics of AI and ML	3	1	0	4	RAI22XX	Program Elective 1	3	0	0	3
RAI2103	Strength of Materials	3	0	0	3	RAI22XX	Flexi Core 2	3	1	0	4
RAI21XX	Flexi Core 1	3	1	0	4	RAI20XX	Open Elective 1	3	0	0	3
RAI2130	Embedded Controllers Lab	0	0	2	1	RAI2230	Sensors and Control System Lab	0	0	2	1
RAI2131	AI and ML Lab	0	0	2	1	RAI2231	Integrated Electronics Lab	0	0	3	2
RAI2170	Project-based Learning-1	0	0	2	1	RAI2270	Project-Based Learning-2	0	0	2	1
	Total Contact Hours (L+T+P)	**18**	**3**	**6**	**24**		**Total Contact Hours (L+T+P)**	**18**	**3**	**7**	**25**
	Fifth Semester						**Sixth Semester**				
Code	Subject Name	L	T	P	C	Code	Subject Name	L	T	P	C
RAI3101	Design of Machine Elements	3	1	0	4	RAI3201	Drives and Automation	3	1	0	4
RAI3102	Deep Learning	3	1	0	4	RAI32XX	Program Elective 4	3	0	0	3
RAI31XX	Flexi Core 3	3	1	0	4	RAI32XX	Program Elective 5	3	0	0	3
RAI31XX	Program Elective 2	3	0	0	3	RAI32XX	Program Elective 6	3	0	0	3
RAI31XX	Program Elective 3	3	0	0	3	RAI30XX	Open Elective 3	3	0	0	3
RAI30XX	Open Elective 2	3	0	0	3	RAI3202	Professional Practice	0	0	2	1
RAI3130	Mobile Robotics Lab	0	0	2	1	RAI3230	Industrial Robotics Lab	0	0	2	1
RAI3131	Modeling and Simulation Lab	0	0	2	1	RAI3231	Drives and Automation Lab	0	0	3	1
RAI3170	Project Based Learning 3	0	0	2	1	RAI3270	Project-based Learning 4	0	0	3	3
	Total Contact Hours (L+T+P)	**18**	**3**	**6**	**24**		**Total Contact Hours (L+T+P)**	**15**	**1**	**9**	**22**
	Seventh Semester						**Eighth Semester**				
Code	Subject Name	L	T	P	C	Code	Subject Name	L	T	P	C
RAI41XX	Program Elective 7	3	0	0	3	RAI4270	Major Project	0	0	0	12
RAI41XX	Program Elective 8	3	0	0	3						
RAI40XX	Open Elective 4	3	0	0	3						
RAI40XX	Open Elective 5	3	0	0	3						
RAI4170	Internship (Industry or Research)	0	0	2	1						
	Total Contact Hours (L+T+P)	**12**	**0**	**2**	**13**		**Total Contact Hours (L+T+P)**	**0**	**0**	**0**	**12**

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List of Flexi Core Course

Flexi Core 1	Flexi Core 2	Flexi Core 3
RAI2120: Manufacturing Process **CSE22XX:** Data Structures and Algorithms	**RAI2220:** Mobile robots **CSE21XX:** Object Oriented Programming	**RAI3120:** Robot Path Planning and Control **CSE31XX:** Relational Database Management Systems

List of Program Electives Courses

IV	V	VI	VII
PE1 • **RAI2240:** Digital System design • **RAI2241:** Robot Gripper Design	**PE2** • **RAI3140:** Signals and Systems • **RAI3141:** Reinforcement Learning in Robotics • **RAI3142:** Smart Materials **PE3** • **RAI3150:** Cyber Physical System • **RAI3151:** Digital Signal Processing • **RAI3152:** Advance Control Systems	**PE 4** • **RAI3240:** Modelling and Simulation of UAV • **RAI3241:** Biomedical Robots • **RAI3242**: Pneumatics and Hydraulics for Robots • **RAI3243:** Electronics for Robotics **PE5** • **RAI3150**: Design and Analysis of Algorithms • **RAI3151**: Machine learning for Robotics • **RAI3152**: Sustainable energy systems in Robotics **PE6** • **RAI3261:** Robotics vision and image processing • **RAI3262:** Wireless Sensor Networks • **RAI4163:** Production and Operations Management	**PE 7** • **RAI4140:** AI in Agriculture • **RAI4141:** Smart Manufacturing • **RAI4142:** Robot Process Automation **PE8** • **RAI4151:** PLC and SCADA • **RAI4152:** Collaborative Robots • **RAI4153:** AI in Industrial applications • **RAI4154:** Ethics and Social implications in AI

List of Open Electives Courses

Graded OE	Non-Graded OE
OE1 RAI0001: Fundamental of Robotics **OE2 RAI0002:** Automation in Industry **OE3 RAI0003:** Building Automation **OE4 RAI0004:** Sensor Technologies **OE5 RAI0005:** Smart Agriculture **OE6 RAI0006:** Manufacturing Process	

Degree: Bachelor of Technology in (Hons) Robotics and Artificial Intelligence
Total Credit: 178 (160 + 18*)

	Third Semester						Fourth Semester				
Code	Subject Name	L	T	P	C	Code	Subject Name	L	T	P	C
MEE2001	Engineering Economics	3	0	0	3	MAS21XX MEE22XX	Statistics & Probability	3	0	0	3
MBB2101	Management of Technology	3	0	0	3	RAI2201	Sensors and Control System	3	1	0	4
RAI2101	Embedded Controllers	3	1	0	4	RAI2202	Robot Kinematics and Dynamics	3	1	0	4
RAI2102	Basics of AI and ML	3	1	0	4	RAI22XX	Program Elective 1	3	0	0	3
RAI2103	Strength of Materials	3	0	0	3	RAI22XX	Flexi Core 2	3	1	0	4
RAI21XX	Flexi Core 1	3	1	0	4	RAI20XX	Open Elective 1	3	0	0	3
RAI2130	Embedded Controllers Lab	0	0	2	1	RAI2230	Sensors and Control System Lab	0	0	2	1
RAI2131	AI and ML Lab	0	0	2	1	RAI2231	Integrated Electronics Lab	0	0	3	2
RAI2170	Project-based Learning-1	0	0	2	1	RAI2270	Project-Based Learning-2	0	0	2	1
	Total Contact Hours (L+T+P)	**18**	**2**	**7**	**24**		**Total Contact Hours (L+T+P)**	**18**	**2**	**9**	**25**
	Fifth Semester						**Sixth Semester**				
Code	Subject Name	L	T	P	C	Code	Subject Name	L	T	P	C
RAI3101	AI in Robotics	3	1	0	4	RAI3201	Drives and Automation	3	1	0	4
RAI3102	Deep Learning	3	1	0	4	RAI32XX	Program Elective 4	3	0	0	3
RAI31XX	Flexi Core 3	3	1	0	4	RAI32XX	Program Elective 5	3	0	0	3
RAI31XX	Program Elective 2	3	0	0	3	RAI32XX	Program Elective 6	3	0	0	3
RAI31XX	Program Elective 3	3	0	0	3	RAI30XX	Open Elective 3	3	0	0	3
RAI30XX	Open Elective 2	3	0	0	3	RAI3202	Professional Practice	0	0	2	1
RAI3130	Mobile Robotics Lab	0	0	2	1	RAI3230	Industrial Robotics Lab	0	0	2	1
RAI3131	Modeling and Simulation Lab	0	0	2	1	RAI3231	Drives and Automation Lab	0	0	3	1
RAI3170	Project Based Learning 3	0	0	2	1	RAI3270	Project-based Learning 4	0	0	3	3
RAI3181	Research Methodology	1	0	0	1	RAI328X*	Honors Elective1	3	0	0	3
	Total Contact Hours (L+T+P)	**18**	**3**	**6**	**25**		**Total Contact Hours (L+T+P)**	**18**	**1**	**9**	**25**
	Seventh Semester						**Eighth Semester**				
Code	Subject Name	L	T	P	C	Code	Subject Name	L	T	P	C
RAI41XX	Program Elective 7	3	0	0	3	RAI4270	Major Project	0	0	0	12
RAI41XX	Program Elective 8	3	0	0	3	RAI428X*	Honors Project	0	0	0	8
RAI40XX	Open Elective 4	3	0	0	3						
RAI40XX	Open Elective 5	3	0	0	3						
RAI4170	Internship (Industry or Research)	0	0	2	1						
RAI418X*	Honors Elective 2	3	0	0	3						
RAI418X*	Honors Elective 3	3	0	0	3						
	Total Contact Hours (L+T+P)	**18**	**0**	**2**	**19**		**Total Contact Hours (L+T+P)**	**0**	**0**	**0**	**20**

Degree: Bachelor of Technology in (Hons) Robotics and Artificial Intelligence
Total Credit: 178 (160 + 18*)

List of Flexi Core Course

Flexi Core 1	Flexi Core 2	Flexi Core 3
RAI2120: MANUFACTURING PROCESS **CSE22XX:** Data Structures and Algorithms	**RAI2220:** Mobile robots **CSE21XX:** Object Oriented Programming	**RAI3120:** Robot Path Planning and Control **CSE31XX:** Relational Database Management Systems

List of Program Electives Courses

IV	V	VI	VII
PE1 • **RAI2240:** Digital System design • **RAI2241:** Robot Gripper Design	**PE2** • **RAI3140:** Signals and Systems • **RAI3141:** Reinforcement Learning in Robotics • **RAI3142:** Smart Materials **PE3** • **RAI3150:** Cyber Physical System • **RAI3151:** Digital Signal Processing • **RAI3152:** Advance Control Systems	**PE 4** • **RAI3240:** Modelling and Simulation of UAV • **RAI3241:** Biomedical Robots • **RAI3242**: Pneumatics and Hydraulics for Robots • **RAI3243:** Electronics for Robotics **PE5** • **RAI3150**: Design and Analysis of Algorithms • **RAI3151**: Machine learning for Robotics • **RAI3152**: Sustainable energy systems in Robotics **PE6** • **RAI3261:** Robotics vision and image processing • **RAI3262:** Wireless Sensor Networks • **RAI4163:** Production and Operations Management	**PE 7** • **RAI4140:** AI in Agriculture • **RAI4141:** Smart Manufacturing • **RAI4142:** Robot Process Automation **PE8** • **RAI4151:** PLC and SCADA • **RAI4152:** Collaborative Robots • **RAI4153:** AI in Industrial applications • **RAI4154:** Ethics and Social implications in AI

List of Open Electives Courses

Graded OE	Non-Graded OE
OE1 RAI0001: Fundamental of Robotics **OE2 RAI0002:** Automation in Industry **OE3 RAI0003:** Building Automation **OE4 RAI0004:** Sensor Technologies **OE5 RAI0005:** Smart Agriculture **OE6 RAI0006:** Manufacturing Process	

List of Program Electives for Hons.

VI / VII
RAI3281: Robot System Design – **Pre-Requisite:** Nil **RAI4181:** Robot Safety & Maintenance – **Pre-Requisite:** Nil **RAI4182:** Data Analytics and Visualization **Pre-Requisite:** Nil

Degree: B. Tech Robotics and Artificial Intelligence with Minor Specialization in "3D Printing"

Total Credit: 178 (160 + 18*)

	Fifth Semester						**Sixth Semester**				
Code	**Subject Name**	**L**	**T**	**P**	**C**	**Code**	**Subject Name**	**L**	**T**	**P**	**C**
RAI3181	Research Methodology	1	0	0	1	**RAI329X***	Minor Elective1	3	0	0	3
	Seventh Semester						**Eighth Semester**				
Code	**Subject Name**	**L**	**T**	**P**	**C**	**Code**	**Subject Name**	**L**	**T**	**P**	**C**
RAI419X*	Minor Elective 2	3	0	0	3	RAI4271*	Minor Specialization Project	0	0	0	8
RAI419X*	Minor Elective 3	3	0	0	3						

List of Program Electives Program Electives for Minor Specialization

VI / VII
RAI3290: Additive Manufacturing- Pre-Requisite-(**RAI4103:** Manufacturing Process course offered as OE6 by Mechatronics Department) **RAI4191:** Software Skills for 3D Printing, Pre-Requisite-Nil **RAI4192:** Product Design and Development, Pre-Requisite-Nil

Eligibility Criteria for Minor Specialization[i]

SN	**Minor Program**	**Eligible Branch of Students**	**@ Offering Department**	**Award of Degree**
1	3D Printing	All (Except Mechanical Engineering and Electronics & Communication Engineering)	Mechatronics	B. Tech. in "**branch"** name with Minor in 3D Printing

[i] For Eligibility criteria, refer the AICTE APH.

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MEE2001 ENGINEERING ECONOMICS [3 0 0 3]

Concept and Value Analysis, Economic Decision Making, Types of Estimates, Accounting and Control, Elements of Cost, Prime Cost, Overheads, Types of Cost, Process Cost & Cost of Production, Break Even Analysis, Inventory Control & Management, EOQ, Financial Analysis, Simple payback, Return on Investment, NPV (Net Present Value), IRR (Internal rate of Return), Life Cycle Cost Method, Sensitivity Analysis, Project Financing Options. Budget and Budgetary Control, Concept of Budgeting, Type of Budgets. Risk - Risk vs Return, System Concept and Value Analysis, System Analysis & System Engineering, Value Analysis. Replacement Analysis, Depreciation, Network Analysis, Network Techniques, PERT (Programme evaluation and review technique), CPM (Critical Path Method).

References:

1. R. Panneerselvam, *Engineering Economics*, 2nd ed., New Delhi, India: Prentice Hall of India, 2014.
2. P. L. Mehta, *Managerial Economics*, 3rd ed., New Delhi, India: Sultan Chand & Sons, 2004.
3. E. L. Grant, W. G. Ireson, and R. S. Leavenworth, *Principles of Engineering Economic Analysis*, 5th ed., Hoboken, NJ, USA: John Wiley & Sons, 2004.
4. G. J. Thuesen, W. J. Fabrycky, and H. G. Thuesen, *Engineering Economy*, 7th ed., New Delhi, India: Prentice Hall of India, 2002.

MBB2101 MANAGEMENT OF TECHNOLOGY [3 0 0 3]

Invention and Innovation; Market analysis; Technology transition; Market survey technique; Analysing marketing opportunities; Ansoff Matrix; Project Formulations (1, 2 and 3) based on market survey technique; Commercialization; Financial Management; Human Resource Management; Leadership; Intellectual Property Rights.
NPTEL Link: https://onlinecourses.swayam2.ac.in/cec24_mg28/preview

References:

1. V. S. P. Rao, *Business, Entrepreneurship and Management*, 1st ed., New Delhi, India: Vikas Publications, 2010.
2. D. F. Kuratko and R. M. Hodgetts, *Entrepreneurship: Theory, Process and Practice*, 9th ed., Boston, MA, USA: Cengage Learning, 2016.
3. R. Roy, *Entrepreneurship*, 1st ed., New Delhi, India: Oxford University Press, 2008.

RAI2101 EMBEDDED CONTROLLERS [3 1 0 4]

Comparison between microprocessor and microcontroller, Introduction to embedded controllers, Architecture of microcontroller: Register Banks; Programming model, Pin diagram & details, I/O Ports & details. Assembly Language Programming: Assembler Directives, Addressing Modes, Instruction set, calculation of delay, delay programs. Timers, Counters, Serial Communication, Interrupts, Programming examples. Programming in Embedded C: Data types in embedded C, arithmetic & logic operators, control statements and loops in embedded C, functions & arrays, Hardware Interfacing: Stepper Motor, Seven Segment Display, LCD, Design of Microcontroller based systems: Introduction to other Microcontroller families (PIC, AVR and ARM).

References:

1. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, *8051 Microcontroller and Embedded Systems Using Assembly and C*, 2nd ed., New Delhi, India: Pearson Education, 2008.

2. K. J. Ayala, *The 8051 Microcontroller and Embedded Systems Using Assembly and C*, 2nd ed., Boston, MA, USA: Cengage Learning, 2005.
3. V. Deshmukh, *Microcontrollers—Theory and Applications*, 1st ed., New Delhi, India: Tata McGraw-Hill, 2005.
4. K. U. Rao and A. Pallavi, *8051 and MSP430 Microcontrollers: Architecture, Programming and Applications*, Hoboken, NJ, USA: Wiley, 2012.

RAI2102 BASICS OF AI AND ML [3 1 0 4]

Introduction: Basics of Artificial Intelligence - Definition and history of AI, Basic concepts and goals of AI, Applications and impact of AI in various fields, Problem-Solving and Search Algorithms, Problem-solving methods in AI, Search algorithms: breadth-first search, depth-first search, A* search, other models, Heuristic search techniques. Machine Learning Fundamentals: Introduction to machine Learning—Supervised learning, unsupervised learning, and reinforcement learning; Evaluation metrics in machine learning, Regression and Classification Algorithms: Regression Models: Linear regression, performance Metrics. Ensemble methods; Introduction to Neural Network.

References:

1. E. Alpaydin, *Introduction to Machine Learning*, 4th ed., Cambridge, MA, USA: MIT Press, 2020.
2. S. Marsland, *Machine Learning: An Algorithmic Perspective*, 2nd ed., Boca Raton, FL, USA: Chapman and Hall/CRC, 2015.
3. S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed., Upper Saddle River, NJ, USA: Prentice Hall, 2020.
4. E. Rich, K. Knight, and S. B. Nair, *Artificial Intelligence*, 3rd ed., New Delhi, India: Tata McGraw-Hill, 2009.
5. S. Marsland, *Machine Learning: An Algorithmic Perspective*, 2nd ed., Boca Raton, FL, USA: Chapman and Hall/CRC, 2015.

RAI2103 STRENGTH OF MATERIALS [3 0 0 3]

Stress, Strain and Deformation of Solids, Concept of stress and strain. Deformation of simple and compound bars under axial load, Hooke's law, Stress-Strain diagrams for materials, factor of safety, Elongation of tapering bars of circular and rectangular cross sections, Saint Venant's principle, Thermal stress, Elastic constants, Strain energy, Biaxial state of stresses, Deformation in thick & thin cylindrical and spherical shells, Stresses on inclined plane, Principal planes and stresses, Shear force and Bending Moment in Cantilever, Simply supported and Overhanging beams, Theory of simple bending, Effect of shape of beam section on stress induced with different types of loading , Expression for transverse shear stress in beams, Bending and shear stress distribution diagrams for circular, rectangular, 'I', and 'T' sections, Torsion Analysis of torsion of circular bars, Shear stress distribution for Solid and hollow circular section, Stepped shaft, Twist and torsion stiffness, Fixed and simply supported shafts, Introduction, short and long columns. Euler's theory; Assumptions, Buckling load for different end conditions, Limitations of Euler's theory. Rankine-Gordon's formula for columns.

References:

1. F. P. Beer and E. R. Johnston, *Mechanics of Materials*, 8th ed., New York, NY, USA: McGraw-Hill Education, 2020.
2. S. M. A. Kazimi, *Solid Mechanics*, 1st ed., New Delhi, India: Tata McGraw-Hill, 2008.

3. G. H. Ryder, *Strength of Materials*, 3rd ed., New Delhi, India: Macmillan India Ltd., 2002.

CSE 2101 DATA STRUCTURES & ALGORITHMS [3 1 0 3]

Introduction: algorithm specification; Performance analysis: time and space complexity, asymptotic notation; C concepts: pointers, functions, arrays, passing arrays to functions through pointers, dynamic memory allocation, bubble sort , insertion sort , selection sort, structures, arrays of structures, passing structures to functions; List: ADT, array and its types, implementation, operations, linked list and its types, implementation and operations; Stack: ADT, implementations using array and linked list, operations and its applications; Queue: ADT, implementations using array and linked list, operations and its applications; Tree: terminologies, different types, representation of binary tree using array and linked structure, binary search tree, different operations (recursive and non-recursive), heap, heap sort, priority queue, AVL trees, B-tree; Graph: Introduction, representation, operations and applications; Searching techniques and hashing.

References:

1. S. Tannenbaum and J. Augenstein, *Data Structures Using C*, 3rd ed., New Delhi, India: Pearson India, 2006.
2. E. Horowitz and S. Sahni, *Fundamentals of Data Structures in C*, 2nd ed., Hyderabad, India: Universities Press, 2008.
3. B. A. Forouzan and R. F. Gilberg, *A Structured Programming Approach Using C*, 2nd ed., Boston, MA, USA: Cengage Learning, 2003.

RAI2120 MANUFACTURING PROCESS [3 1 0 4]

Metal Casting Process, Classification of metal casting, Pattern Allowances, Molding Materials, Gating system design. Casting defects, Causes and remedies, Inspection of castings. Introduction to Machine Tools, Classification of machine tool, Mechanics of Metal Cutting Principles of metal machining, cutting tools and tool materials, tool signature, mechanics of chip removal, tool wear, tool life, economics of machining. Metal Joining Processes Principle of welding, soldering, Brazing and adhesive bonding. Classification of welding and allied processes. Resistance welding Spot, Projection and seam welding process, atomic hydrogen, ultrasonic, Plasma and laser beam welding, Electron beam welding, and special welding process e.g. TIG, MIG, friction and explosive welding. Metal Shaping and Forming Metal, MUJ working, Elastic and plastic deformation, Hot and cold working, Rolling, Principle and operations, Forging, Forging operations, extrusion, Wire, and tube drawing processes. Forging Principle of forging tool design.

References:

1. S. Kalpakjian and S. R. Schmid, *Manufacturing Engineering and Technology*, 8th ed., New Delhi, India: Pearson Education, 2019.
2. Ghosh and A. K. Malik, *Manufacturing Science*, 2nd ed., New Delhi, India: Affiliated East-West Press Pvt. Ltd., 2010.
3. P. C. Sharma, A Textbook of Production Technology, 1st ed., New Delhi, India: S. Chand and Company, 2009.
4. R. K. Jain, Production Technology: Manufacturing Processes, Technology and Automation, 1st ed., New Delhi, India: Khanna Publishers, 2010.

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RAI2130 EMBEDDED CONTROLLERS LAB [0 0 2 1]

Introduction to Microcontroller, arithmetic instructions, array handling and code conversions, bit manipulations and logic instructions, timer/counter programming, serial communication and interrupts, interfacing ADC, interfacing stepper motor, interfacing DAC, interfacing buzzer, interfacing seven segment display, interfacing LCD, implementing a traffic light controller.

References:

1. M. Fisher, *ARM® Cortex® M4 Cookbook*, 1st ed., Birmingham, UK: Packt Publishing, 2016.
2. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, 8051 Microcontroller and Embedded Systems Using Assembly and C, 2nd ed., New Delhi, India: Pearson Education, 2006.
3. W. Wolf, Computers as Components: Principles of Embedded Computing System Design, 3rd ed., San Francisco, CA, USA: Morgan Kaufmann Publishers, 2012.
4. J. Yiu, The Definitive Guide to ARM Cortex M3 and Cortex M4 Processors, 3rd ed., Amsterdam, Netherlands: Elsevier, 2017.
5. P. Marwedel, Embedded System Design, 3rd ed., Berlin, Germany: Springer, 2011.

RAI2131 AI AND ML LAB [0 0 2 1]

Uninformed search, Heuristic search, stochastic search, adversarial search, Machine Learning: basic concepts, Use any programming language for the applications: linear models, perceptron, neural networks, naive Bayes, decision trees, ensemble, logistic regression, and unsupervised learning, Performance metrics.

References:

1. E. Rich, K. Knight, and S. B. Nair, *Artificial Intelligence*, 4th ed., New Delhi, India: Tata McGraw-Hill, 2024.
2. H. P. Langtangen, *Python Scripting for Computational Science*, 4th ed., Berlin, Germany: Springer Publishers, 2017.
3. N. R. Ceder, *The Quick Python Book*, 3rd ed., Shelter Island, NY, USA: Manning Publications Co., 2015.
4. G. James, D. Witten, T. Hastie, and R. Tibshirani, *An Introduction to Statistical Learning with Applications in R*, 2nd ed., New York, NY, USA: Springer, 2021.

MAS2001: STATISTICAL METHODS AND PROBABILITY THEORY [3 0 0 3]

Probability Theory and Random Variables: Probability (Only One Lecture), Random variables, Cumulative distribution functions, Discrete random variables, Continuous random variables, Independent random variables, Probability mass and density functions, Expectation of random variables, Chebyschev's inequality, Central limit theorem. Probability distribution: Binomial, Poisson, Uniform, Normal, Exponential Theory of Estimation: Maximum Likelihood and method moment estimation, Sufficient statistics, Bayesian estimation, Confidence intervals for means. Tests of Statistical Hypothesis: Introduction, Parameter and Statistic, Standard error, Statistical hypotheses, Critical region, Tests of hypotheses and significance, Type I and Type II errors, level of significance. level of significance, Test about one mean, Test about equality of two means, Test of variances, Chi square test, Analysis of Variance.

References:

1. P. L. Meyer, *Introduction to Probability and Statistical Applications*, 2nd ed., New Delhi, India: Oxford and IBH Publishing, 1980.
2. J. E. Miller, M. L. Freund, and R. Johnson, *Probability and Statistics for Engineers*, 8th ed., New Delhi, India: PHI, 2011.
3. R. V. Hogg and A. T. Craig, *Introduction to Mathematical Statistics*, 6th ed., New Delhi, India: Pearson Education, 2012.
4. S. M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, 5th ed., Amsterdam, Netherlands: Elsevier, 2014.

RAI 2201 SENSORS AND CONTROL SYSTEM [3 1 0 4]

Sensor: Classification of sensors, Sensor calibration, Temperature Sensors, Proximity Sensors - Magnetic, Inductive, Capacitive, Optical, Range Sensors –Ultrasonic, Reflective, LIDAR. Piezo-electric sensor, Tactile sensor, Strain Gage, Hall Effect transducer, Piezo-electric sensor, Smart Sensors Film sensor, MEMS & Nano Sensors, LASER sensors, Gyroscope. Pressure, force, displacement, acceleration, vibration, weight, and flow measurement. Data acquisition and SCADA Control: Open loop-and closed loop control systems, mathematical modelling, transfer functions, Time response characteristics, stability, Frequency response analysis, Basics of control design- PID.

References:

1. D. Patranabis, *Sensors and Transducers*, 2nd ed., New Delhi, India: PHI, 2019.
2. D. V. S. Murty, *Transducers and Instrumentation*, 3rd ed., New Delhi, India: Prentice Hall India, 2018.
3. K. Shawhney, *A Course in Electrical and Electronics Measurements and Instrumentation*, 3rd ed., New Delhi, India: Dhanpat Rai & Sons, 2017.
4. J. Nagarath and M. Gopal, *Control System Engineering*, 5th ed., New Delhi, India: Wiley Eastern, 2018.
5. N. S. Nise, *Control Systems Engineering*, 7th ed., New Delhi, India: Wiley Eastern, 2020.
6. K. Ogata, *Modern Control Engineering*, 5th ed., New Delhi, India: Prentice Hall of India, 2018.

RAI 2202 ROBOT KINEMATICS AND DYNAMICS [3 1 0 4]

Introduction: Laws of Robotics, Robot Classifications, Links, Joints, Degrees of Freedom (DOF), Coordinate Systems, Work Volume, Precision, Repeatability, Accuracy, Position & Orientation: Roll, Pitch, Yaw, Overview of End Effector Selection and Serial Manipulators, Kinematics: Forward & Inverse Kinematics: Geometrical and Algebraic Approaches, Transformation Matrices: Translation, Rotation, Euler Angles, Homogeneous Transformation, D-H Convention and Solutions for Kinematics Problems, Dynamics: Kinetic and Potential Energy, Lagrangian and Euler-Lagrange Equations, Newton-Euler Formulation, Jacobian Matrix in Dynamics, Inertia Matrix, Equations of Motion for Robots, Inverse Dynamics, Basic of Trajectory Planning.

References:

1. J. J. Craig, *Introduction to Robotics: Mechanics and Control*, 4th ed., Upper Saddle River, NJ, USA: Pearson Education International, 2018.
2. S. B. Niku, *Introduction to Robotics: Analysis, Control, An Indian Adaptation*, 2nd ed., New Delhi, India: Wiley, 2016.

3. S. K. Saha, *Introduction to Robotics*, 1st ed., New Delhi, India: Tata McGraw-Hill Education, 2008.
4. M. Spong, S. Hutchison, and M. Vidyasagar, *Robot Modeling and Control*, 2nd ed., Hoboken, NJ, USA: John Wiley and Sons Inc., 2006.
5. K. M. Lynch and F. C. Park, *Modern Robotics: Mechanics, Planning, and Control*, 1st ed., Singapore: Cambridge University Press, 2017.
6. Ghosal, *Robotics: Fundamental Concepts and Analysis*, 1st ed., New Delhi, India: Oxford University Press, 2014.

RAI2240 DIGITAL SYSTEM DESIGN [3 0 0 3]

Number system, Boolean algebra, Logic gates, Concept of K-Maps reduction, Design of combinational circuits: Adder, Subtractor, Encoder, Decoder, Multiplexer, Demultiplexer. Design sequential circuits by using memory elements like latches, flip-flops, Counters, Registers, Synchronous Counters, Asynchronous counters, Logic families, Analysis and Design of Finite State Machines, Sequence Generator and Sequence Detector-Lock out condition, Design examples, Basics of FPGA Architecture.

References:

1. M. Morris Mano, *Digital Design*, 5th ed., Upper Saddle River, NJ, USA: Prentice Hall Publishers, 2013.
2. Kumar, *Switching Theory and Logic Design*, 2nd ed., New Delhi, India: PHI Learning, 2015.
3. D. J. Comer, *Digital Logic State Machine Design*, 4th ed., Oxford, UK: Oxford University Press, 2019.
4. S. Palnitkar, *Verilog HDL: A Guide to Digital Design and Synthesis*, 2nd ed., Upper Saddle River, NJ, USA: Prentice Hall PTR, 2003.

RAI2241 ROBOT GRIPPER DESIGN [3 0 0 3]

Introduction to Robot Grippers: Overview of robotic gripping systems, Classification of grippers, Applications of robot grippers in industry, Gripper Kinematics and Dynamics: Grasping theory: Force closure vs. Form closure, Kinematics of different gripper types, Dynamics of gripping and object manipulation, Actuation technologies: pneumatic, hydraulic, electric, shape memory alloys (SMA), and soft actuators, Materials and Manufacturing of Grippers: Material selection, Additive manufacturing (3D printing) of grippers, Durability, flexibility, and cost considerations, Gripper Design Considerations: Design for specific tasks, Design constraints: load, object size, and environment, Integration with robotic arms.

References:

1. G. J. Monkman, *Robot Grippers*, 1st ed., Cham, Switzerland: Springer, 2016.
2. M. T. Mason, *Mechanics of Robotic Manipulation*, 1st ed., Cambridge, MA, USA: MIT Press, 2001.
3. K. S. Fu et al., *Robotics: Control, Sensing, Vision, and Intelligence*, 1st ed., New York, NY, USA: McGraw-Hill, 1987.
4. M. F. Ashby, *Materials Selection in Mechanical Design*, 4th ed., Oxford, UK: Butterworth-Heinemann, 2016.
5. M. T. Mason and J. K. Salisbury, *Robot Hands and the Mechanics of Manipulation*, 1st ed., Cambridge, MA, USA: MIT Press, 1985.
6. C. Laschi and B. Mazzolai, *Soft Robotics: Trends, Applications and Challenges*, 1st ed., Cham, Switzerland: Springer, 2016.

RAI2220 MOBILE ROBOTS [3 1 0 4]

Types of locomotion, hopping robots, legged robots, wheeled robots, stability, manoeuvrability, controllability; Mobile robot kinematics and dynamics: Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, Control theory - Control design basics, Cruise-Controllers, Performance Objectives. Simple robot - State space model, Linearization, LTI system, stability. PID control, basic control algorithms, Sensors for mobile robots - Classification, performance, uncertainty in sensors, wheel sensor, heading sensor, accelerometers, inertial measurement, motion sensor, range sensors.

References:

1. R. Siegwart and I. R. Nourbakhsh, *Introduction to Autonomous Mobile Robots*, 2nd ed., Cambridge, MA, USA: The MIT Press, 2016.
2. P. Corke, *Robotics, Vision and Control: Fundamental Algorithms in MATLAB*, 1st ed., Springer Tracts in Advanced Robotics, 2017.
3. S. M. LaValle, *Planning Algorithms*, 1st ed., Cambridge, UK: Cambridge University Press, 2006.
4. S. Thrun, W. Burgard, and D. Fox, *Probabilistic Robotics*, 1st ed., Cambridge, MA, USA: MIT Press, 2005.
5. E. R. Melgar and C. C. Diez, *Arduino and Kinect Projects: Design, Build, Blow Their Minds*, 1st ed., 2012.
6. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, *Principles of Robot Motion: Theory, Algorithms, and Implementations*, 1st ed., New Delhi, India: PHI Ltd., 2005.

CSE2122: OBJECT ORIENTED PROGRAMMING USING PYTHON [3 1 0 4]

Introduction: Programming a computer, Programming languages; Python basics: Getting started with Python, Essentials of a Python program, Integers, Floating-point numbers, Strings; Variables and scope: Variables, Modifying values, Type conversion; Selection control statements: if statement, Boolean values, operators, and expressions; Collections: Lists, Tuples, Sets, Ranges, Dictionaries, Conversion, Sequences; Loop control statements: while, for statements, Nested loops, Iterables, iterators and generators, Comprehensions, The break and continue statements; Functions: Input parameters, Return values, Default parameters, *args and **kwargs, Decoratorss, Lambdas,Generator functions and yield; Data Structure in Python: Array, Linked List, Stack, Queue, Tree, Searching and Sorting; Object Oriented programming: OOP's Concepts, Classes, and Objects: Defining and using a class, Instance attributes, Class attributes, Class decorators, inspecting an object, Constructor, Abstraction, Composition; Inheritance: Types of Inheritance. overriding magic methods; I/O and Errors Handling: Errors, exceptions, handling exceptions, Debugging programs, Logging, Testing; Packaging: Modules, Packages, Documentation; File Handling: Introduction, Access Methods, Read and write operation, Working with directories; Python Libraries: Pandas, Matplotlib, NUMPY.

References:

1. M. T. Goodrich, R. Tamassia, and M. H. Goldwasser, *Data Structures and Algorithms in Python: An Indian Adaptation*, 1st ed., New Delhi, India: Wiley Publication, July 2021.
2. D. Phillips, *Python 3 Object-Oriented Programming: Build Robust and Maintainable Software with Object-Oriented Design Patterns in Python 3.8*, Birmingham, UK: Packt Publishing, 2020.
3. W. J. Chun, *Core Python Applications Programming*, 3rd ed., Upper Saddle River, NJ, USA: Prentice Hall Publishers, 2012.
4. J. Grus, *Data Science from Scratch: First Principles with Python*, Sebastopol, CA, USA: O'Reilly Media, 2019.
5. Boschetti and L. Massaron, *Python Data Science Essentials: A Practitioner's Guide Covering Essential Data Science Principles, Tools, and Techniques*, 3rd ed., 2020.

Degree: Bachelor of Technology in Robotics and Artificial Intelligence
Total Credits: 160 & 178
Details Syllabus

RAI2230 SENSOR AND CONTROL SYSTEMS LAB [0 0 2 1]

Behavior of proximity sensors. Switching frequency and switching distance of proximity sensor. Characteristics of Temperature sensor, Strain Measurement, Displacement measurement using LVDT. Sensor data analysis using Raspberry Pi, open and close loop control, implementation of PID controller.

References:

1. K. Sawhney, *A Course in Electrical and Electronics Measurements and Instrumentation*, Dhanpat Rai & Sons, 2023.
2. D. Patranabis, *Sensors and Transducers*, 2nd ed., PHI Learning, New Delhi, 2023.
3. D. V. S. Murty, *Transducers and Instrumentation*, Prentice Hall India, 2023.
4. J. Nagarath and M. Gopal, *Control System Engineering*, New Delhi: New Age International, 6th ed., 2017.
5. N. S. Nise, *Control Systems Engineering*, Wiley, 8th ed., 2020
6. K. Ogata, *Modern Control Engineering*, 5th ed., Prentice Hall, 2010.

RAI2231 INTEGRATED ELECTRONICS LAB [0 0 3 2]

Introduction and Analog circuit designs using 741 IC, linear applications of Op-amps design of rectifiers, DACs and ADCs, filters, multivibrators & Schmitt trigger using 555 IC, regulators. Digital circuit designs-combinational circuit's, implementation of Boolean functions and arithmetic circuits, multiplexers, encoders, decoders, code converters, design of sequential circuits- ripple counters, shift registers and ring counters, synchronous counters, sequence detectors.

References:

1. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, 4th ed. New York, NY, USA: McGraw-Hill, 2014.
2. M. M. Mano and M. D. Ciletti, *Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog*, 6th ed. Upper Saddle River, NJ, USA: Pearson, 2023.

RAI2270 PROJECT BASED LEARNING-I [0 0 2 1]

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.