2018 Syllabus: B. Tech. in MECHATRONICS ENGINEERING

Year	THIRD SEMESTER						FOURTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
II	MAT 2151	Engineering Mathematics – III	2	1	0	3	MAT 2261	Engineering Mathematics – IV	2	1	0	3
	MTE 2151	Data Structures and Algorithms	2	1	0	3	MTE 2251	Automated Manufacturing Systems	3	0	0	3
	MTE 2152	Digital System Design	3	1	0	4	MTE 2252	Design of Machine Elements	3	1	0	4
	MTE 2153	Microcontroller based System Design	4	0	0	4	MTE 2253	Linear Control Theory	3	1	0	4
	MTE 2154	Robotics I	2	1	0	3	MTE 2254	Linear Integrated Circuits and Applications.	3	1	0	4
	MTE 2155	Sensors and Instrumentation	4	0	0	4	*** ****	Open Elective – I				3
	MTE 2161	Microcontroller Lab	0	0	3	1	MTE 2261	CAD and Kinematics' Simulation Lab	0	0	3	1
	MTE 2162	Robotics Lab I	0	0	3	1	MTE 2262	Integrated Electronics Lab	0	0	3	1
	MTE 2163	Sensors and PLC lab	0	0	3	1	MTE 2263	Manufacturing Processes Lab	0	0	3	1
			17	**4**	**9**	**24**			**14**	**4**	**9**	**24**
	Total Contact Hours (L + T + P)		**30**				**Total Contact Hours (L + T + P) + OE**		**27 + 3 = 30**			
III	**FIFTH SEMESTER**						**SIXTH SEMESTER**					
	HUM 3051	Engg Economics and Financial Management	2	1	0	3	HUM 3052	Essentials of Management	2	1	0	3
	MTE 3151	Digital Signal Processing	3	1	0	4	MTE 3251	Automobile Engineering	2	1	0	3
	MTE 3152	Electric Drives	3	1	0	4	MTE 3252	Energy and Heat Transfer	3	1	0	4
	MTE 3153	Hydraulics and Pneumatics Systems	2	1	0	3	MTE 3253	Program Elective – I	3	0	0	3
	MTE 3154	Theory of Machines	3	1	0	4	MTE 3254	Program Elective – II	3	0	0	3
	*** ****	Open Elective – II				3	*** ****	Open Elective – III				3
	MTE 3161	Drives, Controls and Modelling Lab	0	0	6	2	MTE 3261	Hydraulics Lab	0	0	3	1
	MTE 3162	Robotics Lab II	0	0	3	1	MTE 3262	IIoT Lab	0	0	6	2
							MTE 3263	Pneumatics Lab	0	0	3	1
			13	**5**	**9**	**24**			**13**	**3**	**12**	**23**
	Total Contact Hours (L + T + P) + OE		**27 + 3 = 30**				**Total Contact Hours (L + T + P) + OE**		**28 + 3 = 31**			
IV	**SEVENTH SEMESTER**						**EIGHTH SEMESTER**					
	MTE ****	Program Elective – III	**3**	**0**	**0**	**3**	MTE 4298	Industrial Training				1
	MTE ****	Program Elective – IV	**3**	**0**	**0**	**3**	MTE 4299	Project Work/Practice School				12
	MTE ****	Program Elective – V	**3**	**0**	**0**	**3**	MTE 4296	Project Work (Only for B. Tech. Hons.)				20
	MTE ****	Program Elective – VI	**3**	**0**	**0**	**3**						
	MTE ****	Program Elective – VII	**3**	**0**	**0**	**3**						
	*** ****	Open Elective – IV				**3**						
			15	**0**	**0**	**18**						**13**
	Total Contact Hours (L + T + P) +OE		**15 + 3 = 18**									

Minor Specialization		
I. Electric Vehicle Technology MTE 4054: Vehicle Dynamics MTE 4072: Hybrid Vehicle Technology MTE 4084: Power Sources for Electric Vehicles MTE 4085: Modelling of Electric Vehicles **II. Industrial IoT Systems** MTE 4055: Database Management Systems MTE 4056: Information Security for Industrial Automation MTE 4057: Internetworking for Industries MTE 4058: Principles of Cryptography **III. Robotics and Automation** MTE 4059: Artificial Intelligence MTE 4060: Robot Dynamics and Control MTE 4061: Robot Path Planning and Mobile Robots MTE 4062: Soft Robotics **IV. Business Management** HUM 4051: Financial Management HUM 4052: Human Resource Management HUM 4053: Marketing Management HUM 4054: Operation Management	**V. Computational Mathematics** MAT 4051: Applied Statistics and Time Series Analysis MAT 4052: Computational Linear Algebra MAT 4053: Computational Probability and Design of Experiments MAT 4054: Graphs and Matrices **VI. Material Science** PHY 4015: Physics of Low Dimensional Materials PHY 4052: Physics of Photonic & Energy Storage Devices CHM 4051: Chemical Bonding CHM 4052: Chemistry of Carbon Compound **Other Electives** MTE 4051: Automotive Control Systems MTE 4052: Battery and Fuel Cell Technology MTE 4053: Mechatronics modelling of Hybrid Vehicles MTE 4063: Big Data Analytics MTE 4064: Building Automation MTE 4065: Computer Architecture and Real time Systems MTE 4066: Computer Networks and Communication Protocols MTE 4067: Design of Mechanical Drives MTE 4068: Dynamics and Controls of Mechatronics Systems MTE 4069: Electric Vehicle Machines and Drives MTE 4070: Embedded Systems and RTOS MTE 4071: Engineering Materials	MTE 4073: Machine Learning MTE 4074: Machine Tool Technology MTE 4075: Machine Vision and Image Processing MTE 4076: Mechanical Vibrations MTE 4077: Micro Electro Mechanical Systems MTE 4078: Micro-manufacturing Systems MTE 4079: Nanotechnology MTE 4080: Production Operations and Management MTE 4081: Robotics II MTE 4082: Systems Modelling and Simulation MTE 4083: Wireless Sensor Networks **Open Electives** MTE 4301: Autonomous Robots MTE 4302: Electric Vehicle Technology MTE 4303: Hydraulics and Pneumatics Systems MTE 4304: Industrial IoT MTE 4305: Introduction to Robotics MTE 4306: Mechatronics Systems

THIRD SEMESTER

MAT 2151: ENGINEERING MATHEMATICS - III [2 1 0 3]

Vector Calculus: Gradient, divergence and curl, their physical meaning and identities. Line, surface and volume integrals. Green's theorem, statements of divergence and Stoke's theorems, applications. Fourier series: Fourier series of periodic functions, Euler's formulae. Fourier series of odd and even functions and functions with arbitrary period. Half range expansions. Fourier integrals. Sine and cosine integrals, Fourier transform, Sine and cosine transforms. Harmonic analysis. Partial differential equations: Basic concepts, solutions of equations involving derivatives with respect to one variable only. solutions by indicated transformations and separation of variables. Derivation of one-dimensional wave equation (vibrating string) and its solution by using the method of separation of variables. D'Alembert's solution of wave equation. Derivation of one dimensional heat equation using Gauss divergence theorem and solution of one dimensional heat equation. Solution by separation of variables. Numerical Methods: Finite difference expressions for first and second order derivatives (ordinary and partial). Solution of boundary valued problems, Classification of second order partial differential equations. Numerical solutions of Laplace and Poisson equations by standard five point formula and heat and wave equations by explicit methods.

References:

1. Kreyszig, Erwin, *Advanced Engineering Mathematics*, John Wiley & Sons, (5e), 2010.
2. S. S. Sastry, *Introductory Methods of Numerical Analysis*, (2e), 1990, Prentice Hall.
3. B. S. Grewal, *Higher Engineering Mathematics*, 1989, Khanna Publishers
4. Murray R. Spiegel, *Vector Analysis*, 1959, Schaum Publishing Co.

MTE 2151: DATA STRUCTURES AND ALGORITHMS [2 1 0 3]

Accessing variables through pointers, Pointers arithmetic and arrays, Pointers and Functions, Recursion- definition, Recursive programs, Stacks, Queues, Evaluation of expressions, Linked lists-singly, doubly, header node, circular along with application. Trees- Binary trees, In-order, Preorder and Post order traversal of Trees. Creation, Insertion and Deletion operations on Binary search tree. Sorting – Bubble sort, Selection sort, Merge sort, Quick sort, Heap sort. Searching – Linear search, Binary search. Horspool algorithm, Open Hash table, Floyd's algorithm, Warshall's algorithm, Prim's algorithm, Kruskal's algorithm, Dijkstra's algorithm.

References:

1. Behrouz A. Forouzan, Richard F. Gilberg, *A Structured Programming Approach Using C*, (3e), Centage Learning India Pvt. Ltd. India, 2007.
2. Ellis Horowitz, Sartaj Sahni, Susan Anderson and Freed, *Fundamentals of Data Structures in C*, (2e), Silicon Press, 2007.
3. Richard F. Gillberg, Behrouz A. Forouzan, *Data Structures, A Pseudo code Approach with C*, (2e). Centage Learning India Pvt. Ltd. India, 2009.
4. Tenenbaum Aaron M., Langsam Yedidyah, Augenstein Moshe J., *Data Structures using C*, (1e), Pearson Prentice Hall of India Ltd., 2007.
5. Debasis Samanta, *Classic Data Structures*, (2e), PHI Learning Pvt. Ltd., India, 2010.

MTE 2152: DIGITAL SYSTEM DESIGN [3 1 0 4]

Design of combinational circuits by using principles of minimization of Boolean equations: Adder, Subtractor, Encoder, Decoder, Multiplexer, Demultiplexer. Concept of K-Maps reduction, Design sequential circuits by using memory elements like latches and flip-flops, FPGA Architectures-ACTEL, XILINX and ALTERA logic families, logic module, switching technology, I/O cells, Programmable interconnect, Modeling of circuits at structural, dataflow, behavioral abstraction levels using Verilog HDL modeling language.

References:

1. Morris Mano, *Digital design*, (3e), Prentice Hall of India, 2002.
2. A. Anand Kumar, *Switching Theory and Logic Design*, (2e), Prentice Hall of India, 2009.
3. Samir Palnitkar, *Verilog HDL: A Guide to Digital Design and Synthesis*, (2e), Prentice Hall PTR, 2003.
4. David J Comer, *Digital Logic State Machine Design*, (3e), Oxford University Press, 2012.
5. Neil H.E Weste and Kamran Eshraghian, *Principles of CMOS VLSI Design*, (2e), Wesley, 1998.

MTE 2153: MICROCONTROLLER BASED SYSTEM DESIGN [4 0 0 4]

Introduction to Microcomputer Based Digital Control, Significance and History of Microcomputer Technology, Basic function of Microcomputer Control, Selection of various Processor Architecture, Digital Vs Analog Control. Basics on Microcomputer Components ,Microcomputer Architecture and Advanced Architecture ,Microprocessor Architecture & Instruction Set, ,Memory & IO ,Processor Technologies: Microcontroller, Digital Signal Processor, RISC, Parallel Processors, Introduction to Advanced RISC Machines, History of ARM Microcontroller, ARM

Architecture, programming model. Instruction set of ARM and Programming. THUMB mode: Programmers model. THUMB instruction set: Instruction format, THUMB Conditional, branch instruction, THUMB data processing instructions. Introduction to Programming ARM in C. Digital I/O – I/O ports programming using C, Interfacing of ARM. Coprocessor – architecture: Introduction to Arm cortex, M3 programmer model, stack and interrupts. Case studies: ARM based system developments. Development of System: Hardware and Software Tradeoffs in design, Development Systems ,Evaluation Boards , PC Based Add-On Cards , Advanced Workstation Based systems.

References:

1. Jonathan Valvano, *Embedded Systems: Real-Time Operating Systems for ARM Cortex-M Microcontrollers*, Create Space Independent Publishing Platform, 2017
2. J.R.Gibson"*ARM Assembly Language-an Introduction*", Dept. of Electrical Engineering and Electronics, The University of Liverpool, 2007
3. Unsalan, Cem, H. Deniz Gurhan, and M. Erkin Yucel. *Programmable Microcontrollers: Applications on the MSP432 LaunchPad*. McGraw Hill Professional, 2017.
4. Bai, Ying. *Microcontroller Engineering with MSP432: Fundamentals and Applications*. Crc Press, 2016.

MTE 2154: ROBOTICS I [2 1 0 3]

Introduction: Definition of robots, definition and factors affecting the control resolution, spatial resolution, accuracy and repeatability, specification of a robot, actuators and sensors, drives and transmission systems used in robotics. Spatial descriptions and transformations: Descriptions, operators, transform equations. Introduction to Lie algebra and Rodrigues's rotation formula and Quaternions. Manipulator kinematics: Link description, manipulator kinematics, actuator space, joint space, and Cartesian space, kinematics of two industrial robots, frames with standard names. Introduction to kinematics of parallel manipulators, Closed loop constraints, four bar mechanism, Stewart platform. Inverse manipulator kinematics: Pieper's solution when three axes intersect. Manipulator dynamics: Introduction, acceleration of a rigid body, mass distribution, Newton's equation, Euler's equation iterative Newton-Euler dynamic formulation. Trajectory generation: Path description and generation, joint-space schemes Cartesian-space schemes. Linear control of manipulators: Introduction, feedback and closed-loop control, second-order linear systems, control of second-order systems, trajectory-following control, continuous vs. discrete time control, modeling and control of a single joint.

References

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, (3e), PHI, 2005.

2. C. Peter., *Robotics, Vision and Control: Fundamental Algorithms in MATLAB*. Vol. 73. Springer, 2011.
3. G. Ashitava, *Robotics: Fundamental Concepts and Analysis*, Oxford University Press, 2006.
4. Murray, Richard M., Zexiang Li, S. Shankar Sastry, and S. Shankara Sastry, *A Mathematical Introduction to Robotic Manipulation*, CRC press, 1994.
5. S. Bruno and O. Khatib, *EDS: Springer handbook of Robotics*, Springer, 2016.

MTE 2155: SENSORS AND INSTRUMENTATION [4 0 0 4]

Units and standards, calibration, static and dynamic characteristics of an instrument, error analysis, electromechanical indicating instruments. Material science concepts: materials used as sensors and transducers. analog and digital voltmeters, ammeters, multimeters, DC bridges, AC bridges, fault detection- short circuit, open circuit, shielding and grounding methods, introduction to sensors and transducers, potentiometers, physical quantities and their measurements- strain, force, speed, velocity, acceleration, proximity and range, temperature, pressure, flow, level, O2 sensors, breathalyzers, display device- digital CRO, data storage, introduction to data acquisition, elements of data acquisition system, concept of signal conditioning. PLC: Programming formats using contacts and coils, latching etc. Converting simple relay logic diagram to PLC ladder diagram, Digital logic implementation in ladder programming, Timer and counter functions, Arithmetic functions, R-trig / F- trig pulses, shift registers, sequence functions, PID principles and functional block, position indicator with PID control. Communication: Industrial Process Automation, Networks and Protocols: AS-i, CAN, MODBUS, PROFIBUS-DP, Wi-Fi, WiMAX, Connectors.

References:

1. A.K. Sawhney, *A course in Electrical and Electronic Measurements and Instrumentation,* (19e), Dhanpat Rai & Co. Publishers, 2012.
2. A. K. Sawhney, *A course in Mechanical Measurement and Instrumentation*, (9e), Dhanpat Rai & Co. Publishers, 2012.
3. R.K. Rajput, *Electrical & Electronic Measurements & Instrumentation*, (2e), S.Chand Publishers, 2010.
4. Bela G. Liptak, *Process Measurement and Analysis*, (4e), CRC press, 2003.
5. Liptak, B.G. (Ed.), *Instrument engineers' handbook, Vol. 3: Process software and digital networks*, (1e) CRC Press, Boca Raton, London, 2002.

MTE 2161: MICROCONTROLLER LAB [0 0 3 1]

Microcontroller: Introduction to ARM: Assembly and C programming, arithmetic instructions, array handling and code conversions, bit manipulations and logic instructions, timer/counter programming, serial communication and interrupts, interfacing ADC, interfacing DC and stepper

motor, interfacing DAC, interfacing seven segment display, interfacing LCD, implementing a traffic light controller.

References:

1. Texas Instruments ARM Cortex M4 - MSP432 Reference Manual.
2. Texas Instruments Robotics System Learning Kit. http://www.ti.com/lit/ml/slay052a/slay052a.pdf
3. Code Composer Studio for Simplelink MSP432. http://www.ti.com/lit/ug/slau575k/slau575k.pdf
4. Bai, Ying. Microcontroller Engineering with MSP432: Fundamentals and Applications. Crc Press, 2016.

MTE 2162: ROBOTICS LAB I [0 0 3 1]

Robotics: Simulation of forward and inverse kinematics in computational software, Preliminary idea of master-slave control including hardware interfacing. Introduction to Robot Studio an offline Programming Tool. Defining Targets and Path Generation. Creating a Custom Tool and Defining a Work object. Conveyor Tracking using Robot Studio. Online programming using IRB2600 and Teachpendant, control of Digital Inputs and Outputs through IRB2600 Robot, automation applications with industrial robot IRB2600 and collaborative robot Universal Robot UR5. Control of Stepper Motor and servo motor actuators using Raspberry PI. PID Control of Lego Line Following Robot. Robot Vision- Part Shape Detection using Sherlock –Image Processing Software. Food Quality Inspection. Colour Detection using Sherlock- Image Processing Software.

References:

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, (4e), Pearson, 2017.
2. Rafael Gonzalez, Richard Woods, *Digital Image processing*, (4e), Pearson, 2017.
3. Operating manual RobotStudio, ABB Robotics, 2021.
4. IRC5, Robotware 6.02, R15.2, User Documentation Rev C.
5. Sherlock Machine Vision Software User's Reference Manual, for Software versions 7.1.x and 7.2.x.
6. Universal Robots, Core training reference guide.
7. Universal Robots, Advanced training reference guide.

MTE 2163: SENSORICS AND PLC LAB [0 0 3 1]

Behavior of inductive, magnetic, reflection light scanner, and one way barriers, reflection light barrier OBS and an ultrasonic sensor. Path power characteristic curve of inductive analog encoder,

reduction factor of reflection light scanner OJ, fitted with an optical waveguide. Response curve of inductive sensor, capacitive sensor, magnetic field sensors. Switching frequency and switching distance and hysteresis of NBN, CJ, MB, OJ. Calculation of maximum admissible velocity of an object using ultrasonic sensor.
Introduction of PLC, study basic components, networking and different programming technique. Of PLC. Study NO, NC and holding circuit programs, Implement of Simple Ladder program, to study basic functions of timers, counters, math, logical and program control instructions. Study different applications using ladder logic.

References:

1. *Siemens PLC manual*, Siemens.
2. *PLC training practice module*, BOSCH REXROTH manual Germany 2011.
3. John W. Webb and Ronald A. Reiss, *Programmable logic controllers-Principle and applications*, (5e), PHI, 2005.
4. *Sensorics training system practice module*, BOSCH REXROTH manual, Germany 2011.
5. *Sensors in theory and practice*, BOSCH REXROTH AG Germany 2007.

FOURTH SEMESTER

MAT 2261: ENGINEERING MATHEMATICS IV [2 1 0 3]

Probability: Introduction, finite sample spaces, conditional probability and independence, Baye's theorem, one dimensional random variable, mean, variance. Two and higher dimensional random variables: mean, variance, correlation coefficient. Distributions: Binomial, Poisson, uniform, normal, gamma, Chi-square and exponential distributions, simple problems. Moment generating function, Functions of one dimensional and two dimensional random variables, Sampling theory, Central limit theorem and applications. Finite difference expressions for first and second order derivatives (ordinary and partial): Solution of boundary value problems, Numerical solutions of Laplace and Poisson equations by standard five point formula and heat and wave equations by explicit methods. Difference equations: Difference equations representing physical systems, difference operator, the z transforms, properties of z transforms, initial and final value theorems, solution of difference equations by the method of z transforms.

References:

1. P. L. Meyer, *Introduction to Probability and Statistical Applications*, (2e), American Publishing Co., 1979.
2. Kreyszig Erwin, *Advanced Engineering Mathematics*, John Wiley & Sons, 2010.
3. Duffy Dean G, *Advanced Engineering Mathematics with MATLAB*, CRC Press, 2016.

4. Jeffrey Alan, *Advanced Engineering Mathematics*, Academic Press, 2001.

MTE 2251: AUTOMATED MANUFACTURING SYSTEMS [3 0 0 3]

Overview of Manufacturing and Automation: Production systems, Automation in production systems, Automation principles and strategies, Manufacturing operations, production facilities. Additive Manufacturing : Process Chain for Additive Manufacturing Processes, Rapid Prototyping Data Formats, Liquid Based Process, Rapid Freeze Prototyping, Solid Based Process, Powder Based Process, Rapid Tooling Application in design, engineering, analysis and planning, Applications. Subtractive Manufacturing: Computer numerically controlled machining, Numerical control in Non-Traditional Machining, Adoptive control Machining system. Basics of CNC programming (Simulation). Flexible Manufacturing System: Group Technology, Cellular Manufacturing, Quantitative Analysis of Cellular Manufacturing (Rank order Clustering), Flexible Manufacturing system (FMS), Quantitative analysis of FMS (Bottleneck model), Computer Aided Process Planning (CAPP). Product Life Cycle and Data Management (PLDM): Components of PLM, phases of PLM, PLM feasibility study, PLM visioning. PLM Strategies, Strategies for recovery at end of life, recycling. Product Data Managment systems and importance, barriers to PDM implementation.

References:

1. C.K. Chua, K.F. Leong, C.S. Lim, *Rapid Prototyping: Principles and Applications*, (3e), 2010.
2. Gibson, I, Rosen, D W., and Stucker, B., *Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer, 2014.
3. Groover Mikell P, *Automation, Production Systems, and Computer Integrated manufacturing*, (4e), Prentice Hall of India. New Delhi, 2016.
4. Kalpakajain, *Manufacturing Engineering and Technology*, (4e), Addison Wesley, New York, 2014.
5. Saaksvuori, Antti, Immonen, Anselmi, *Product Lifecycle Management*, (2e), Springer-Verlag Berlin Heidelberg, 2005.

MTE 2252: DESIGN OF MACHINE ELEMENTS [3 1 0 4]

Stresses and strains, bending moments, uniaxial, biaxial and complex loading systems, principal planes and stresses, Theory of pure bending, stress distribution in beams, stresses in shafts, stepped and hollow shafts, theories of failure, deflection of beams by double integration method and Macaulay's method, stress concentration, fatigue loading, S-N diagram, design of transmission shafts, ASME code for shaft design, design of helical springs, terminologies of springs, static and fatigue load on springs, concentric springs, design of power screws, stresses in different

components of power screws, torque calculations, efficiency of power screws, design of spur gears, dynamic and wear load based gear design, beam strength and Lewis equation, selection of bearings, lubrication of bearings, specification and selection of ball bearings, sensing and measurement of mechanical motion, computer programs to calculate stresses and deflection in simple machine members.

References:

1. Timoshenko and Young, *Elements of Strength of Materials*, Tata McGraw Hill, New Delhi, 2003.
2. Popov E.P., *Engineering Mechanics of Solids*, Prentice Hall India, New Delhi, 2001.
3. Beer F. P. and Jonhston R, *Mechanics of Materials*, (3e), MacGraw Hill Book Company, 2002
4. Shigley J. E. and Mischke C. R., *Mechanical Engineering Design*, (5e), McGraw Hill Inc, New York. 2004
5. Bhandari V B., *Design of Machine Elements*, (2e), Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.

MTE 2253: LINEAR CONTROL THEORY [3 1 0 4]

Feedback control systems terminologies, control system design process. differential equation of physical systems, linear approximation, frequency domain representation, Time domain analysis and design, first and second order system response analysis, time domain and Steady State Error (SSE), stability, RH criteria, root locus technique. Introduction to compensator design, design of lag, lead, and lag-lead compensating network. Frequency domain analysis- frequency response, Bode plot construction and interpretation of system behaviour, gain margin & phase margin, relation between time domain & frequency domain specification, SSE characteristics from frequency response, control system design simulation analysis.

References:

1. Norman S. Nise, *Control Systems Engineering*, (6e), Wiley India.
2. R.C Dorf, R. H. Bishop, *Modern Control Systems*, (8e), Wesley Longman Inc.
3. B.C. Kuo, F. Golnaraghi, *Automatic Control Systems*, (8e), Wiley India.
4. K. Ogata, *Modern Control Engineering*, (5e), PHI.
5. M. Gopal, *Control System: Principles and Practices*, (4e), TMH.

MTE 2254: LINEAR INTEGRATED CIRCUITS AND APPLICATIONS [3 1 0 4]

Introduction to op-amp using 741IC, linear applications of Op-amp, Operational amplifier and block diagram representation, characteristics of ideal operational amplifier, Open loop and closed

loop operation of operational amplifier, non-linear applications, precision half wave and full wave rectifiers, peak detector, sample and hold circuit, log and antilog amplifiers, analog multipliers and dividers, comparators, designing of filters, design of analog to digital and digital to analog converters, designing of a stable and monostable multivibrator and its applications using 555 timer IC. Operating principle of PLL using 565 IC, and its applications, analysis, design of fixed and adjustable voltage regulators, and its applications.

References:

1. Stanley William D., *Operational Amplifiers with Linear Integrated Circuits*, Prentice Hall, (2e), 2004.
2. Franco Sergio, *Design with Op-amps and Analog Integrated Circuits*, McGraw Hill, (3e), 2002.
3. David L. Terrell and Butterworth – Heinemann, *Op Amps Design, Application, and Troubleshooting*, (2e), 1996.
4. Ramakant A. Gaikwad, *Op-Amps and Linear Integrated Circuits*, Prentice Hall of India, (4e), 2009.
5. Choudhury Roy D and Shail B. Jain, *Linear Integrated Circuits*, Wiley Eastern, (4e), 2011.

MTE 2261: CAD AND KINEMATICS' SIMULATION LAB [0 0 3 1]

2D sketcher exercises of simple machine components, solid modeling and assembly exercise of machine components like 6 axis robot, CPU fan, bench vice, screw jack etc... Kinematic analysis of simple mechanisms like slider crank mechanism, 4 bar mechanism, cam and follower mechanism.

References:

1. Gopalkrishna K. R., *Machine Drawing*, Subhas Publications, Bangalore, 2002.
2. Bhat N.D., *Machine Drawing*, Charotar Publishing House, Anand, 2002.
3. Venugopal K., *Engineering drawing and graphics + Auto CAD*, Newage International ublishers, Delhi 2002.
4. Narayana K.L. and Kannaiah P, *Text Book on Engineering drawing*, Scitech Publications, Chennai 2002.
5. Sham Tickoo, *CATIA – for Engineers and Designers*, Dreamtech Press, New Delhi 2005.

MTE 2262: INTEGRATED ELECTRONICS LAB [0 0 3 1]

Introduction to PSpice, Analog circuit designs using 741 IC linear applications of Op-amps, design of rectifiers, design of DACs and ADCs, design of filters, astable, monostable multivibrators& Schmitt trigger, using 555 IC design and study of astable and monostable multivibrators, using

78xx and LM 317 IC, design and study of regulators. Digital circuit designs- design of combinational circuits implementation of Boolean functions and arithmetic circuits, multiplexers, decoders, code converters, display driver interfaces, design of sequential circuits-design of ripple counters, shift registers and ring counters, design of synchronous counters, design of sequence detectors.

References:

1. Franco Sergio, *Design with Op amps & Analog Integrated Circuits*, McGraw Hill 1997.
2. J. Millman and H. Taub, *Pulse, Digital and Switching Waveforms*, TMH 2002.
3. Morris Mano, *Digital design*, (3e), Prentice Hall of India.
4. Ananda Kumar, *Switching Theory and Logic Design*, Prentice Hall of India, 2009.
5. Vladimirescu, *The PSpice Book*, J. Wiley & Sons, New York, 1994.

MTE 2263: MANUFACTURING PROCESS LAB [0 0 3 1]

Foundry shop: Introduction to molding and pattern materials; use of cores; exercises involving preparation of small sand mould and castings. Forging practice: Introduction to forging tools; exercises on simple smithy; metal cutting machine: preparing the turning models by using lathe; thread cutting; preparing models which includes milling, shaping and grinding (surface); spur gear cutting; CNC demonstration: vertical milling center and turning center.

References:

1. Chaudhury S. K. Hajara & Others, *Elements of Workshop Technologyvol 1 & 2, (5e),*Media Promoters & publishers Pvt.Ltd ., Mumbai, 2004.
2. R.K. Jain, *Production Technology, (2e),* Khanna Publishers, New Delhi, 2002.
3. Raghuwanshi, B.S., *A course in Workshop technology, Vol 1 & II,* DhanpatRai & Sons, New Delhi.

FIFTH SEMESTER

HUM 3051: ENGINEERING ECONOMICS AND FINANCIAL MANAGEMENT [2 1 0 3]

Nature and significance, Micro & macro differences, Law of demand and supply, Elasticity & equilibrium of demand & supply. Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, Present and future worth of single, Uniform gradient cash flow. Bases for comparison of alternatives, Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Future worth amount, Capital recovery with return, Rate of return method, Incremental approach for economic analysis of alternatives, Replacement analysis. Break even analysis for single product and multi product firms, Break even analysis for evaluation of

investment alternatives. Physical & functional depreciation, Straight line depreciation, Declining balance method of depreciation, Sum-of-the-years digits method of depreciation, Sinking fund and service output methods, Costing and its types – Job costing and Process costing, Introduction to balance sheet and profit & loss statement. Ratio analysis - Financial ratios such as liquidity ratios, Leverage ratios, Turn over ratios, and profitability ratios. Safety and Risk, Risk Benefit Analysis and Reducing Risk, Respect for Authority.

References:

1. Prasanna Chandra *Fundamentals of Financial Management*, Tata Mc Graw Hill Companies, New Delhi, 2005.
2. James L. Riggs, David D. Bedworth and Sabah U. Randhawa, *Engineering Economics*, Tata Mc Graw Hill Companies, New Delhi, 2004.
3. Theusen G. J. & Theusen H. G., *Engineering Economics*, Prentice Hall of India, New Delhi, 2005.
4. Blank Leland T, Tarquin Anthony J. *Engineering Economy*, McGraw Hill, 2002.
5. Chan S. Park. *Contemporary Engineering Economics*, Pearson Education, Inc. 2010.
6. Mike W. Martin and Rolan Schinzinger, *Ethics in Engineering*, Tata McGraw Hill, New Delhi, 2003.
7. Govindarajan M., Natarajan S., Senthil Kumar V. S., *Engineering Ethics*, Prentice Hall of India, New Delhi, 2004.
8. Charles B. Fleddermann *Engineering Ethics*, Pearson Prentice Hall, New Jersey, 2012.

MTE 3151: DIGITAL SIGNAL PROCESSING [3 1 0 4]

Introduction to Signal Processing, operations on signals, Properties of signals and systems, Impulse Response and convolution, Sampling, Aliasing, Transform domain analysis of discrete-time systems: Z Transform and application of Z transforms to discrete time systems, Computation of DFT, Fast Fourier Transform. Digital Filter Characteristics and structures, IIR Filter Design using Butterworth and Chebyshev approximations, Impulse invariant and bilinear transformation methods. FIR Filter Design using Window method and Frequency sampling method. Architectural features of Digital signal processors and Case study of TMS320C24x processor. Case study: Sensing, measurement and analysis of mechanical motion, fault analysis.

References:

1. Oppenheim A.V, Willsky A.S, *Signals and Systems*, (2e), PHI,2011
2. Oppenheim A.V. and R.W. Schafer, *Discrete time signal processing*, (2e), Prentice-Hall, 2001.

3. Proakis J.G. and D.G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, (3e), PHI, 2007.
4. Rabiner L.R and Gold D.J, *Theory and Applications of Digital Signal Processing*, (2e), Prentice Hall, 2007.
5. *TMS320F/C24x DSP Controllers, Reference Guide*, June 1999.

MTE 3152: ELECTRIC DRIVES [3 1 0 4]

Introduction to power electronics, switching characteristics, BJT, SCR, MOSFET, triggering methods, PWM methods, controlled rectifiers, loads, freewheeling diodes. DC motors, operating principles, torque speed characteristics, speed control concepts, solid state motor drivers choppers buck, boost, buck-boost, thyristor controlled rectifiers. AC motors, three phase induction motors, operating principles, torque speed characteristics, speed control, solid state motor drivers, ac voltage regulators, inverters, VSI, CSI, single phase induction motors, synchronous motors, linear induction motors, PM synchronous motors, servo motors, switched reluctance motors, BLDC motors, stepper motors. Fundamentals of electric drives, basic components, advantages, closed loop control, speed, torque conventions, steady state equilibrium, and determination of motor power rating.

References:

1. Gopal K. Dubbey, *Fundamentals of Electric Drives*, (2e), Narosa Publishers, 2010.
2. Nagrath I.J. and Kothari D.P., *Electric machines*, (3e), Tata McGraw Hill, 2011.
3. Bimbra P.S., *Power electronics*, (3e), Khanna Publishers, 2010.
4. R. Krishnan, *Electric Motor Drives Modeling, Analysis, and Control*, (2e), Prentice Hall, 2012.

MTE 3153: HYDRAULICS AND PNEUMATICS SYSTEMS [2 1 0 3]

Pneumatic systems, structure and signal flow, compressors, actuators and control valves, single acting and double acting cylinders, manual pneumatics, single and multiple actuators, limit switches, proximity sensors, electro pneumatics and design of electro pneumatic circuits, direction control valves, relay control systems, timers, counters, pressure control valves, closed loop pneumatics and Flow control valves. Hydraulic systems, physical principles of oil hydraulics, hydraulic actuators, valves and accessories, hydraulic power pack, types of hydraulic pumps, accumulator, Filters, hydraulic circuits, regenerative, meter in, meter out, bleed off, sequencing, pressure reducing circuits, electro hydraulic circuits, proportional hydraulics and servo hydraulics.

References:

1. Anthony Esposito, *Fluid power with applications*, Pearson Education, 2003.

2. Andrew A. Parr, *Hydraulics and Pneumatics*, Elsevier Science & Technology Books, (3e) 2011.
3. Scholz D., *Proportional Hydraulics*, Festo Didactic GMBH & Co, Germany, 2002.
4. Majumdar S.R., *Pneumatic Systems - Principles and Maintenance*, Tata McGraw Hill, 2000.
5. Merkle D., Rupp K. and Scholz D., *Electrohydraulics Basic Level TP 601*, Festo Didactic GMBH & Co, Germany, 1994.

MTE 3154: THEORY OF MACHINES [3 1 0 4]

Kinematics and Dynamics, Mechanisms and Machines, Plane and Space Mechanisms, Kinematic Pairs, Kinematic Chains, Kinematic Diagrams, Kinematic Inversion Four Link Planar Mechanisms and their Inversions. Mobility and range of movement. Dynamics of Rotating Bodies- Balancing. Turning Moment Diagram for Engines, Flywheel and Governors. Gears and Gear Trains. Straight line mechanisms, steering mechanisms and universal joint. Dimensional synthesis of mechanism; motion, path and function generation. Advanced synthesis solutions, branch and order defects.

References:

1. John J. Uicker Jr., Gordon R. Pennock, Joseph E. Shigley, *Theory of Machines and Mechanisms*, (5e) OUP USA, 2017.
2. Rattan. S. S, *Theory of Machines*, (4e), Tata Mc Graw Hill, New Delhi, 2017.
3. Bevan. T, *Theory of Machines*, (4e), Laxmi Publications, New Delhi, 2016.
4. Ghosh and Mallick. A. K, *Theory of Machines and Mechanisms*, (3e), Affiliated East West Private Limited New Delhi, 2008.
5. Ballaney P. L, *Theory of Machines and Mechanisms*, Khanna Publishers, New Delhi, 2005

MTE 3161: DRIVES, CONTROLS AND MODELLING LAB [0 0 6 2]

Automation motors and their drivers and controls: Stepper motors, servo motors, linear motors etc.

References:

1. *Drives and Control training system- Practice module,* BOSCH REXROTH manual, Germany 2011.

MTE 3162: ROBOTICS LAB II [0 0 3 1]

Introduction to robot operating system- publisher , subscriber nodes, custom messages, robot motion with turtlesim, robot dynamic simulation in Gazebo and Rviz environments, implementation of robot model with URDF, simultaneous localization and mapping in ROS, introduction to ROS based system for path planning, implementation of model-based controller, integration of machine vision and robotics, basics of swarm robotics, simulation of soft robots, Intelligent control system for multibody system.

References:

1. Anis Koubâa, *Robot Operating System (ROS), the complete reference,* volume 1, Springer International Publishing, 2016.
2. Anis Koubâa, *Robot Operating System (ROS), the complete reference,* volume 2, Springer International Publishing, 2017.
3. Lentin Joseph, *Robot Operating System for absolute beginners*, Apress Media LLC, 2018.
4. Wyatt Newman, *A systematic approach to learning robot programming with ROS*, Chapman and Hall, 2017.
5. Joseph Howse, Prateek Joshi, Michael Beyeler, *OpenCV_Computer Vision projects with Python*, Packt Publishing, 2016.
6. Alvaro Morena, *Artificial Vision and Language Processing for Robotics*, Packt Publishing, 2019.

SIXTH SEMESTER

HUM 3052: ESSENTIALS OF MANAGEMENT [2 1 0 3]

Principles of Management- Planning Definition of management and systems approach, Nature and scope. The functions of managers. Planning-Types of plans, steps in planning, Process of MBO, how to set objectives, strategies, policies ad planning premises, Strategic planning process and tools. Organising-Nature and purpose of organizing. Span of management, factors determining the span, staffing-Basic departmentation, Line and staff concepts, Function authority, Art of delegation, Decentralization of authority. HR theories of planning, Recruitment, Development and training. Theories of motivation, Special motivational techniqu3s. Leadership- leadership behaviour & styles, Managerial grid. Controlling- Basic Control Process, Critical Control points & standards, Budgets, Non-budgetary control devices, Profit and Loss control, Control through ROI, Direct, Preventive Control. Professional ethics – Sense of Engineering ethics, Variety of moral issues, Types of inquiry, Moral dilemmas, Moral Autonomy, Kohlberg's theory, Gilligan's theory, Consensus and Controversy, Models if professional roles, Theories about right action, Self-interest, Customers and Religion, Uses of Ethical Theories. Global issues- Managerial practices in

Japan and USA and application of Theory Z. The nature and purpose of international business & multinational corporations, unified global theory of management. Ethics, Weapons Development, Engineers as Managers, Consulting Engineers, Engineers as Expert Witnesses and Advisers, Moral Leadership, Code of Conduct, Corporate Social Responsibility.

References:

1. Harold Koontz & Heiz Weihrich *Essentials of Management* .Mc Graw Hill, New Delhi, 2012.
2. Peter Drucker *The Practice of Management*, Harper and Row, New York, 2004.
3. Vasant Desai *Dynamics of Entrepreneurial Development & Management*, Himalaya Publishing House, 2007.
4. Poornia M Charantimath *Entrepreneurship Development*. Pearson Education. 2006.
5. Mike W. Martin and Rolan Schinzinger, *Ethics in Engineering*, Tata McGraw Hill, New Delhi, 2003.
6. Govindarajan M., Natarajan S., Senthil Kumar V. S., *Engineering Ethics*, Prentice Hall of India, New Delhi, 2004.

MTE 3251: AUTOMOBILE ENGINEERING [2 1 0 3]

Introduction to automobile engineering: vehicle construction and layouts, chassis, frame and body. Vehicle power supply systems. Transmission systems, clutch types & construction, gear boxes- Hydrodynamic Clutches, Torque Converter. Heating and air conditioning systems. Steering geometry and types of steering gear box, power steering, types of front axle, types of suspension systems, pneumatic and hydraulic braking systems. Desirable tyre properties, conventional tubed & tubeless tyre. Noise vibration and harshness in automobiles, Fundamentals of regenerative braking. Bearing and lubrication systems, environmental management and service information systems. Electrical and lighting systems, Industrial Fabric.

References:

1. Jack Erjavec, Rob Thompson, *Automotive Technology - A Systems Approach*, Cengage (7 ed.), 2018.
2. Richard Stone, Jeffrey K. Ball, *Automotive Engineering Fundamentals*, SAE International (1 ed.), 2004.
3. Trelle Borg, *Automotive Vibration Control Technology: Fundamentals, Materials, Construction, Simulation, and Applications* (1e), Vogel Business Media GmbH & Co. KG, 2015.
4. Kripal Singh, *Automobile Engineering* (4e), Vol-1 and 2, Standard Publishers, Delhi, 2011.
5. Robert Fischer, Ferit Küçükay, Gunter Jürgens, Rolf Najork, Burkhard Pollak, *Automotive transmission book* (4e), Springer International Publishing Switzerland 2015.

MTE 3252: ENERGY AND HEAT TRANSFER [3 1 0 4]

Properties of pure substances and ideal gases, First and second laws of thermodynamics, Energy conversion by cycles, Power-absorbing and power producing cycles. Fluids and Their Properties, Fluid Pressure and Its Measurement, Hydrostatics, Buoyancy and Floatation, Kinematics of Fluid Flow, Venturiemeter and Pitot Tube, Small and Large Orifices, Applications of the Momentum equation, Flow Through pipes, Heat Transfer: Introduction to heat transfer, General Law of Heat Conduction, Steady state one dimensional heat conduction with and without heat generation, Heat Transfer from Extended Surfaces, Heat Transfer by Forced convection and Free convection, Radiation, Heat Exchangers, Cooling of Electronic equipment.

References:

1. Cengel Y Al and Boles M A, *Thermodynamics, An Engineering Approach*, Tata Mc Graw Hill, 2003.
2. Michael J Moran, *Fundamentals of Engineering Thermodynamics*, Wiley India Pvt. Ltd., 2010.
3. Munson B R, Young D F and Okiishi T H, *Fundamentals of Fluid Mechanics*, John Wiley & Sons., Singapore, 2006
4. Kumar D. S, *Fluid Mechanics and Fluid Power Engineering*, Kataria S K and Sons, New Delhi, 2010.
5. Yunus A. Cengel, *Heat Transfer: A Practical Approach*, Tata McGraw Hill Inc., New Delhi, 2005.

MTE 3261: HYDRAULICS LAB [0 0 3 1]

Working principles of hydraulic pumps, hydraulic motors, pressure switch, pressure reducing valve, accumulator, proximity switch, throttle valves, pressure compensated flow control valves and direction control valves. Rigging of manual and electro hydraulic circuits using above components.

References:

1. *Industrial Hydraulics Trainee's manual*, BOSCH REXROTH manual, Germany 2011.

MTE 3262: IIOT LAB [0 0 6 2]

Operation of TwinCAT software, tools and usage. I/O accessing: Analog and Digital detection of sensors. Actuation on sensor detection using TwinCAT. HMI programming using TwinCAT.

Operation of MSP432 microcontroller from TI. Interfacing of communication booster packs for Wi-Fi and Radio communication. Cloud access using BLYNK app. Interfacing the COBOT using Wi-FI. Remote access of 3D-Printer.

References:

1. *Beckhoff: New Automation Technology: Main Catalog, Volume 1, IPC, Motion, Automation,* Germany, 2018.
2. *Beckhoff: New Automation Technology: Main Catalog, Volume 2, I/O,* Germany, 2018.

MTE 3263: PNEUMATICS LAB [0 0 3 1]

Operations of various valves like directional control valves, flow control valves, pressure control valves and switches like pressure switches, proximity switches. Operations of timers and counters. Rigging of manual pneumatic and electro-pneumatic circuits using above valves and switches.

References:

1. *Practice for Professional Pneumatics Trainee's manual*, BOSCH REXROTH manual, Germany 2011.
2. *Practice for Professional Electro-Pneumatics Trainee's manual*, BOSCH REXROTH manual, Germany 2011.

SEVENTH SEMESTER

There are five program electives and one open elective with total of 18 credits to be taught in this semester.

EIGHTH SEMESTER

MTE 4298: INDUSTRIAL TRAINING

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of third semester. Student has to submit to the department a training report in the prescribed format and also make a presentation of the same. The report should include the certificates issued by the industry.

MTE 4299: PROJECT WORK/PRACTICE SCHOOL

The project work may be carried out in the institution/industry/ research laboratory or any other competent institutions. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the department committee as part of project evaluation.

MINOR SPECIALIZATION

I. Electric Vehicle Technology

MTE 4054: VEHICLE DYNAMICS [2 1 0 3]

Introduction to Vehicle System Dynamics: Theoretical background on Vehicle Dynamics and control, Fundamental approach to Vehicle modelling. Longitudinal dynamics: Vehicle Load Distribution – Acceleration, Brake Force Distribution, Braking Efficiency and Braking Distance, Braking, Semi-Trailer. Tire Mechanics: Introduction, Mechanical Properties of Rubber, Slip, Grip and Rolling Resistance, Tire Construction and Force Development, Contact Patch and Contact Pressure Distribution, Tire Brush Model, Lateral Force Generation – Ply Steer and Conicity, Tire Models – Magic Formula, Classification of Tyre Models, and Combined Slip. Lateral Dynamics: Introduction, Bicycle Model, Stability, and Steering Conditions, Effect of road loads on Dynamics of Vehicle – Aerodynamics, rolling resistance, Total road load, Under-steer Gradient and State Space Approach, Parameters affecting vehicle handling characteristics, Subjective and Objective Evaluation of Vehicle Handling and Rollover Prevention. Vertical Dynamics: Introduction, Quarter Car Model, Half Car Model. Introduction to Automotive Safety: Basic concepts, risk evaluation, basic models, accident avoidance, occupant injury prevention, human simulation applications, crash testing, special design models, future vehicle safety.

REFERENCES:

1. Thomas D. Gillespie, Fundamentals of Vehicle Dynamics, SAE International 1997.
2. Reza N. Jazar, "Vehicle dynamics: theory and application". Springer, 2017.
3. Hans B. Pacejka, "Tire and Vehicle Dynamics", Elsevier, 2012.
4. George Peters, Barbara Peters, "Automotive Vehicle Safety", CRC Press, 2002.
5. J Y Wong, "Theory of Ground Vehicles", John Wiley & Sons Inc., 2001.

MTE 4072: HYBRID VEHICLE TECHNOLOGY [2 1 0 3]

History of Hybrid and Electric Vehicles technology, Economics and Environmental aspects of vehicle technologies. Vehicle dynamics-vehicle resistance, dynamic equation, tire ground adhesion, maximum tractive effort, vehicle speed, transmission characteristics, vehicle performance. Hybrid and electric drive trains-configurations of electric vehicles, traction motor characteristics, basic concept of hybrid traction, hybrid drive train architecture – series, parallel torque and speed coupling. Electric propulsion unit: different motors, configuration and control of dc and induction motor drives, introduction to power modulators, control, advanced motor drives for EV: PMSM, BLDC, SRM and SyncRel Motor drives. Energy storage, regenerative breaking, classification of different energy management strategies, fundamentals of regenerative braking. Sizing the drive system- propulsion motor, sizing the power electronics, selecting the energy storage technology, communications, supporting subsystems. Hybridness, PHEV, Range extension vehicles, Control of Hybrid and Electric vehicles: ECU, CAN-bus, Vehicle Dynamics Control. Charging stations. Design of series hybrid drive train.

References:

1. Mehrdad Ehsani, Modern Electric, Hybrid Electric and Fuel Cell Vehicles- *Fundamentals, Theory and Design, (3e),* CRC Press, 2018.

2. Iqbal Hussein, *Electric and Hybrid Vehicles-Design Fundamentals, (2e),* CRC Press, 2010.

3. Gianfranco Pistoia, *Electric and Hybrid Vehicles - Power Sources, Models, Sustainability 3(e), CRC Press 2010.*

MTE 4084 POWER SOURCES FOR ELECTRIC VEHICLES [2 1 0 3]

Introduction, Batteries, Batteries in EV and HEV, Battery Basics: Battery Cell structure, Chemical Reactions, Battery Parameters: Battery capacity, Open circuit voltage, Terminal voltage, State of Charge, Discharge rate, State of discharge, Battery Energy, specific energy, Battery Power, Specific power. Types of batteries and their chemical reactions: Lead-acid and Lithium Batteries and their comparisons, Lithium – Ion Technology: Development of Li-Ion Batteries in electric vehicles, Battery management technologies, BMS key technologies overview: Battery state estimation, Battery equalization, Battery safety management. Performance Modelling of Batteries. Electric Vehicle battery efficiency, Electric vehicle charging and fast charging, EV Battery discharging, EV Battery performance. Vehicle – to – Grid, Grid – to Vehicle. Introduction to Alternative Energy device: Features of Supercapacitors, Basic principles of Supercapacitors, Performance of supercapacitors, Supercapacitors Technologies. Principles of Ultra-high-speed Flywheels, Flywheel technologies in EV and HEV. Hybridization of Energy storage devices.

Passive and Active hybrid energy storage with battery and supercapacitors. Solar based Electric vehicles. Fuel cells: Issues in Fuel Cells, Hydrogen Fuel cells, Types of Fuel Cells: Alkaline, Proton Exchange Membrane, Direct Methonal, Phosphoric Acid, Molten Carbonate, Solid Oxide. Fuel cell model. Cell efficiency and fuel cell voltage, Practical Fuel cell characteristics. Hydrogen storage systems, Fuel cell Hybrid Electric drivetrain.

References:

1. Mehrdad Ehsani, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles- Fundamentals, Theory and Design*, (3e), CRC Press, 2018.
2. Iqbal Hussein, *Electric and Hybrid Vehicles-Design Fundamentals*, (2e), CRC Press, 2010.
3. Gianfranco Pistoia, *Electric and Hybrid Vehicles - Power Sources, Models, Sustainability, Infrastructure, and the Market*, (1e), Elsevier, 2010.
4. Gianfranco Pistoia," *Behaviour of Lithium ion batteries in Electric Vehicles: Battery Health, Performance, Safety, Cost*", (1e), Springer, 2018.

MTE 4085: MODELLING OF ELECTRIC VEHICLES [2 1 0 3]

Introduction to Vehicle Propulsion and Powertrain Technologies: Objectives of vehicle propulsion control. Powertrain architecture and technologies. Importance of Powertrain Modeling and Models – Drivetrain. Motor design, modelling and simulation of drives for Electric Propulsion. Vehicle dynamics control. Modelling and Control of Battery Management Systems. Braking. Design and Control of Hybrid Electric Vehicles. Modelling and control of Fuel cell based EV.

References:

1. Shuvra Das, *Modeling for Hybrid and Electric Vehicles Using Simscape,* Morgan & Claypool Publishers, 2021.
2. Tom Denton, *Electric and Hybrid Vehicles,* Taylor and Francis, 2020.
3. Mehrdad Ehsani, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles- Fundamentals, Theory and Design*, (3e), CRC Press, 2018.
4. Gianfranco Pistoia, *Behaviour of Lithium ion batteries in Electric Vehicles: Battery Health, Performance, Safety, Cost*, (1e), Springer, 2018.
5. Amir Khajepour, Saber Fallah and Avesta Goodarzi, *Electric And Hybrid Vehicles Technologies, Modeling And Control: A Mechatronic Approach,* Wiley 2014.

II. Industrial IoT Systems

MTE 4055: DATABASE MANGEMENT SYSTEMS [2 1 0 3]

Introduction: Database-System Applications, Relational Databases, Data Storage and Querying, Transaction Management, Database Architecture, Database Users and Administrators. Relational Model: Structure of Relational Databases, Database Schemas, Keys, Relational Query Languages, Relational Operations. Database Design and The E-R Model: SQL: SQL Data Definition, SQL Data Types and Schemas, Integrity Constraints, Basic Structure of SQL Queries, Set Operations, Aggregate Functions, Nested Subqueries, Additional Basic Operations Null Values, Atomic Domains and First Normal Form, Decomposition Using Functional Dependencies, Functional Dependency Theory, Algorithms for Decomposition, Decomposition Using Multivalued Dependencies. Transaction Management: Transaction Concept. Data mining: Introduction, Association rules mining, market based analysis, Apriori Algorithm, Partition Algorithm, Pincer – Search Algorithm, Dynamic item set counting algorithm, FP-tree growth Algorithm, PC Tree, Multilevel association rules, Clustering Techniques: Introduction, Clustering paradigms, Partitioning Algorithms, k – Medoid & k- means Algorithms, CLARA, CLARANS, Hierarchical Clustering, DBSCAN.

References:

1. Silberschatz, Korth, Sudarshan, *Database System Concepts*, (6e), McGrawHill, New York, 2011.
2. Ramez Elmasri and Shamkant Navathe, Durvasula V L N Somayajulu, Shyam K Gupta, *Fundamentals of Database Systems*, (6e), Pearson Education, United States of America,2011.
3. Thomas Connolly, Carolyn Begg, *Database Systems – A Practical Approach to Design, Implementation and Management*, (4e), Pearson Education, England, 2005.
4. Peter Rob, Carlos Coronel, *Database Systems–Design, Implementation and Management*, (10e), Course Technology, Boston , 2013.
5. Jiawei Han and Micheline Kamber, *Data Mining Concepts and Techniques*, Morgan Kauffmann Publishers, (2e), 2008

MTE 4056: INFORMATION SECURITY FOR INDUSTRIAL AUTOMATION [2 1 0 3]

Introduction to security, Characteristics of Information, Components of an Information system, Security System Development Lifecycle, The Need for Security- Business Needs first, Threats, Attacks, Intruders, Intrusion detection, Malicious Software – Types, Viruses, Viruses countermeasures, Worms, Introduction to Database security, SQL injection, Reliability and Integrity, Sensitive Data, Inference, Multilevel Databases, Proposals for Multilevel Security, Designs of Multilevel Secure Databases, Transport-level Security- Web security issues, SSL, TLS,

Pretty Good Privacy (PGP), S/MIME, IP security policy, Encapsulating Security payload, Internet Key Exchange, The need for Firewalls, Firewall characteristics, Types of Firewalls, Cyber Crimes and Hackers- Cybercrimes, Cyber criminals, Hackers Hacking topologies, Types of Attacks, Dealing with the rising tide of cybercrimes, Indian Cyber Law offences.

References:

1. William Stallings, *Cryptography and Network Security: Principles and Practice*, (5e), Prentice Hall, 2010.
2. Michael E. Whitman and Herber J. Mattord, *Principles of Information Security*, (4e), Centage Learning India Publication, 2011.
3. Charles P Pfleeger and Shari Lawrence Pfleeger, *Security in Compution*,(4e), PHI, 2009.
4. Joseph Migga Kizza, *A Guide to Computer Network Security*, Springer Intertnation edition, 2009.

MTE 4057: INTERNETWORKING FOR INDUSTRIES [2 1 0 3]

Introduction to Computer Networks**:** Types of networks, Types of transmission media, Concept and types of Multiplexing, Concept and types of Multiple Access techniques, Principles and types of Analog and Digital Modulation. ISO/OSI model: Physical layer: Types of cables, Types of connectors, Communication standards, Data-Link layer, Network Layer: IPv4, IPv6, Routing and Subnetting, Transport Layer: TCP, UDP. Networks in Industrial Process Automation: Introduction to networks in Industrial Process Automation, Networks and Protocols: AS-i, CAN, DeviceNet, Interbus, LON, Foundation Fieldbus, HART, PROFIBUS-PA, BACnet, ControlNet, IndustrialEthernet, Ethernet/IP, MODBUS, PROFIBUS-DP. Fiber Optic Communication: Principles of Fiber-Optic networks, Types of Fiber-Optic cables, Fiber-Optic Network design, Fiber cable installation and setup, Splices and Connectors, Inspection and testing. Radio, Satellite and Infrared Communication: Radio systems, Spread Spectrum techniques, Satellite LANs, Communication bands in satellite communication, Infrared Systems, Very fast Infrared.

References:

1. Liptak, B.G. (Ed.), *Instrument engineers' handbook, Vol. 3: Process software and digital networks*, (1e) CRC Press, Boca Raton, London, 2002.
2. Andrew S. Tanenbaum, *Computer Networks*, (5e), Prentice Hall of India Pvt. Ltd., 2010.
3. William Stallings, *Data and Computer Communications*, (7e), Prentice Hall of India Pvt. Ltd., 2004.

4. James F. Kurose, Keith W. Ross, *Computer Networking (A Top-Down Approach Featuring the Internet)*, (3e), Pearson Education, 2005.
5. Todd Lammle, *Cisco Certified Network Associate-Study Guide*, (2e), Sybex Inc. Publishing. 2000.

MTE 4058: PRINCIPLES OF CRYPTOGRAPHY [2 1 0 3]

Introduction- Security goals, Attacks, Services and Mechanisms, Classical Encryption Techniques, Symmetric Cipher model, Transposition Techniques, The Data Encryption Standard, Block Cipher Operation, Multiple Encryption and Triple DES, Modes of operation, Mathematics of Cryptography- Modular Arithmetic, Fermat's and Euler's theorems, The Chinese Remainder Theorem, AES- structure, Round Functions, Key Expansion, Pseudorandom Number generators, Stream ciphers, RC4, Public-key Cryptosystems, RSA algorithm, Diffie-Hellman Key exchange, El Gamal Cryptosystem, Cryptographic Hash functions- Applications, Hash functions based on Cipher Block Chaining, Secure Hash Algorithm, Message Authentication Function, Message Authentication codes, Digital Signatures.

References:

1. William Stallings, *Cryptography and Network Security: Principles and Practice*, (5e), Prentice Hall, 2010.
2. Behrouz A. Forouzan and Debdeep Mukhopadhyay, *Cryptography and Network Security*, (2e), McGraw Hill, 2008.
3. Atul Kahate, *Cryptography and Network Security*, Tata McGraw-Hill Publishing, 2008.
4. Bruce Schneier, *Applied Cryptography*, (2e), John Wiley and Sons, Inc., 1996.

III. Robotics and Automation

MTE 4059: ARTIFICIAL INTELLIGENCE [2 1 0 3]

Fundamentals: McCulloch – Pitts model, Activation functions, Feed forward and feedback networks, Learning rules. Single layer feed forward networks: Introduction, Perceptron Models, Training Algorithms, Perceptron Convergence theorem, Limitations of the Perceptron Model, Applications. Multi layer feed forward networks: Generalized Delta Rule, Derivation of Back propagation (BP) Training, Summary of Back propagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements. Application of neural networks: Control applications, Character recognition. Fuzzy control: Classical sets & fuzzy sets, fuzzy set operations, Fuzzy relations, membership function, extension principles. Fuzzy Logic System Components: Fuzzification, Membership Value assignment, development of rule base and decision making system, Defuzzification to crisp sets. Application of fuzzy logic. Introduction to Genetic Algorithm

(GA): Principles, Working operation, Design, Applications in control system.Hybrid system: fuzzy- neural systems, Familiarization with MATLAB Fuzzy logic & neural network Toolbox.

References:

1. Jacek M. Zurada, *Introduction to artificial neural networks*, Jaico, 2006.
2. Timothy J. Ross, *Fuzzy logic with engineering applications*, MGH, 2010.
3. Chin-Teng-Lin, C. S. George Lee, *Neural fuzzy systems*, PHI, 1996.
4. Rajasekharan and Rai, *Neural networks, fuzzy logic, genetic algorithms: synthesis and applications*, PHI Publication, 2017.

MTE 4060: ROBOT DYNAMICS AND CONTROL [2 1 0 3]

Review of Robot Kinematics- Transformations: Joint/Task space, Forward Kinematics, Inverse Kinematics, Jacobians, Trajectory Generation, Serial and Parallel Kinematics. Robot Dynamics- Lagrange-Euler Dynamics, Force, Inertia, and Energy, Lagrange's Equations of Motion, Newton's equations of motion, Formulation of robot dynamics, State-Variable Representations, Dynamics of robots with actuators. Robot control problems – Regulator problem, tracking problem, controllers. Set point Tracking, Actuator Saturation, Integrator Anti-windup Compensation, Quadratic Optimal control problem. Nonlinear dynamics and control – Lyapunov stability theorem, Robust control, Feedback-Linearization Controllers, Lyapunov Designs, Variable-Structure Controllers , Saturation-Type Controllers. Inverse dynamics controllers, Force control, Stiffness control, Impedance control, Hybrid Position/Force Control, Reduced state modeling and control, Impedance Control, Stiffness and Compliance, Under-actuated System.

References:

1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, *Robot Modeling and Control*, (2e), John Wiley and sons, 2009.
2. Frank L. Lewis, *Robot Manipulator Control- Theory and Practice*, (2e), CRC Press, 2003.
3. Mark W. Spong, *Robot Dynamics and Control*, (2e), John Wiley and sons, 2009.
4. Yoshikawa, *Foundations of Robotics: Analysis & Control*, (1e), Prentice Hall India, 2009.

MTE 4061: ROBOT PATH PLANNING AND MOBILE ROBOTS [2 0 3 3]

Autonomous mobile robots - Locomotion - Wheeled locomotion- Robot kinematics models & constraints, Mobile robot workspace. Configuration Space – Obstacles space, dimensions of configuration space, topology of configuration space, parameterization, transformations, Potential Functions, Gradient descent. Implementation in plane- computation, local minima problem.

Algorithms – Analysis and complexity, running time, complexity, completeness. Visibility graph, Graph Search A*, Weighted A*, Anytime & Incremental Search D*, Road Maps - Generalized Voronoi Graph (GVG), GVG – transversality, connectivity, opportunist path planning.Cell Decomposition – Trapezoidal decomposition, Morse cell decomposition, Visibility based decomposition. Sampling Based Algorithms, Rapidly Exploring Random Trees (ERT), Control based planning, Manipulation planning, Optimal motion planning, Feedback motion planning. Motion Planning – Motion planning under kinematics and dynamic constraints, Trajectory planning, Non-holonomic constraints, Path planning, Combined path planning and control.

List of Experiments:

1. Implement Dijikstra's algorithm for a mobile robot
2. Implement A* algorithm for a mobile robot
3. Extend A* algorithm to a C-space for 2 degree planar manipulator
4. Implement Probabilistic Road Maps for more than 3 degree of freedom manipulator
5. Implement Artificial Potential Functions for path planning.
6. Executing any one of the above mentioned algorithms for planning a path and then control a Lego robot to follow the path generated.

References:

1. Fahimi, Farbod, *Autonomous robots: modeling, path planning, and control*. Vol. 107. Springer Science & Business Media, 2008.
2. H. Choset, K. M. Lynch, S. Hutchinson, G. A. Kantor, W. Burgard, L. E. Kavraki, S. Thrun *Principles of Robot Motion: Theory, Algorithms, and Implementations*, MIT Press, Cambridge, MA, 2005.
3. S. M. LaValle, *Planning Algorithms*, Cambridge University Press, Cambridge, UK, 2006.

MTE 4062: SOFT ROBOTICS [2 1 0 3]

Bio robotics, biomimetics, nature-inspired designs, materials for soft robot, biological analogy, Soft Actuators, Soft Sensors, Electroactive Polymer, Ionic Polymer Metal Composites, Shape Memory Alloy, Artificial Muscles based on Electric/Pneumatics, Thermal/Chemical Actuation , Introduction to 3D Printing, 3D printing of Soft Materials, Hyper-elasticity, Finite Element Analysis, Stretchable Electronics, Soft Electrical Materials, Soft Mechanical Composite Materials, Gradient of Material Stiffness, Mechanical Soft Materials, Pneumatic Artificial Muscles, Mathematical Modelling of Flexible Manipulator, Introduction to Euler Cautchy Elasticity Problem Hyper-redundant kinematic structures, Resolution of inverse kinematics, Mathematical formulation for animating flexible structure, Bio-mimetics (modelling of snake/earthworm, caterpillar etc), Continuum Mechanics, Eigenvalues and Eigenvectors, Geometric interpretation of eigenvectors, Cayley-Hamilton theorem, Principal Component Analysis, Singular Value

Decomposition, ISO-Map Dimensional Reduction technique, Case Studies on wearable Robotics, Space Robotics, Deep-Sea Robotics, Healthcare Systems, Under-actuated Robots.

References:

1. Matthew Borgatti, Kari Love, Christopher G. Atkeson, *MAKE: Soft Robotics – A DIY Introduction to Squishy, Stretchy, and Flexible Robots, 2018.*
2. Jog, C.S., Foundations and applications of mechan*ics: Volume I: Continuum mechanics*, Narosa Publishing House, 2007.
3. Alexander Verl, Alin Albu-Schaffer, Oliver Brock, Annika Raatz, *Soft Robotics Transferring Theory to Application*, Springer, 2015.
4. Jaeyoun (Jay) Kim, *Microscale Soft Robotics: Motivations, Progress, and Outlook*, Springer International Publishing, 2017.
5. Cecilia Laschi, Jonathan Rossiter, Fumiya Iida, Matteo Cianchetti, Laura Margheri, *Soft Robotics: Trends, Applications and Challenges*, Springer International Publishing, 2016.

OTHER ELECTIVES

MTE 4051: AUTOMOTIVE CONTROL SYSTEMS [2 1 0 3]

Overview of Automotive Control Systems, Automotive Control-System Design Process, Identifying the Control Requirements, Review of Engine Modeling, Engine Operations, Engine Control Loops, Control-Oriented Engine Modeling, Vehicle Dynamics, Coordinates and Notation for Vehicle Dynamics, Longitudinal Vehicle Motion, Lateral Vehicle Motion, Vertical Vehicle Motion, Human Factors in Vehicle Automation, Driver Modeling, Design, Modeling, and Control of Automotive Transmission Systems, Powertrain Control Systems, Air–Fuel Ratio Control, Control of Spark Timing, Idle-Speed Control, Transmission Control, Design, Modeling, and Control of Hybrid Systems: Control of Hybrid Vehicles, Series, Parallel, and Split Hybrid Configurations, Hybrid Vehicle-Control Hierarchy, Control Concepts for Series Hybrids, Control Concepts for Parallel Hybrids, Control Concept for Split Hybrids, Feedback-Based Supervisory Controller for PHEVs, Modeling and Control of Fuel Cells for Vehicles: Modeling of Fuel-Cell Systems, Control of Fuel-Cell Systems, Control of Fuel-Cell Vehicles, Parametric Design Considerations, Cruise and Headway Control, Antilock Brake and Traction-Control Systems, Vehicle Stability Control, Four-Wheel Steering, Active Suspensions, Overview of Intelligent Transportation Systems, Preventing Collisions, Longitudinal Motion Control and Platoons, Automated Steering and Lateral Control.

References:

1. Zong Xuan, *Automotive propulsion systems*, CRC press, 2015.

2. A. Galip Ulsoy, Ann Arbor, *Automotive Control Systems*, Cambridge university press, 2012.
3. M. Thoma, F. Allgöwer, M. Morari, *Identification for automotive systems*, Springer, 2012.
4. B.T. Fijalkowski, *Automotive Mechatronics: Operational and Practical Issues*, Springer, 2011.

MTE 4052: BATTERY AND FUEL CELL TECHNOLOGY [2 1 0 3]

Introduction to Functional Safety Following ISO 26262, Description of Automotive Battery System Architecture, Classification and Application of Safety Measures for Automotive Battery Systems, Organizational and Technical Safety Measures, Application of Measures at Battery System Units, Considering non-E/E Measures in the Concept Phase. Specific Hazards of Electric Vehicles, Applicable Design Approach for Batteries, Automotive Battery Design, Modularity and Battery Components, Safety-Relevant Design Parameters, Structural Vehicle Design Process Including Batteries, Standard Approach and
Requirements, Batteries in Crash Tests and Crash Simulation, Finite Elements Model of the Battery, Modelling of Mechanical Deformation, Modelling of Material and Joint Failure, Modelling of Electrical Contact and Leakage, Experimental (Brief Description of the Test Rig, Testing Method, Gas Analysis, Cell-Components Identification, Lithium-Ion Cells, Electrical Characterization), Typical Course of a Thermal Runaway Experiment, Thermal-Runaway Experiments, Gas Analysis, Empirical Models, Equivalent Circuit Modelling, Parametrization, Mechanistic Models, Charge Transfer, Ion Transport, Electron Transport, Porous Electrodes, Intercalation, Heat Generation, Cell Ageing, Large-Scale Modelling, Thermal Behaviour, Electrical Behaviour, Distributed-Micro-Structure Modelling, Mobility Demands and Primary Energy Resources, Internal Combustion Engines and Their Impact on Air Quality, Climate Change and Carbon-Free Fuel Chance, Hydrogen Production, Hydrogen Distribution, Hydrogen Storage, Basic Concepts of Electrochemistry, Proton Exchange Membrane Fuel Cells, Sensitivity of PEM Stacks to Operating Conditions, Durability of PEM Fuel Cells, Design of Hydrogen Fuel Cell. Systems for Road Vehicles, Hydrogen Fuel Cell Systems: Preliminary Remarks, Hydrogen Feeding System, Air Feeding Systems, Thermal Management System, Integrated Fuel Cell System: Efficiency, Dynamics, Costs.

References:

1. Mehrdad Ehsani, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles- Fundamentals, Theory and Design*, (3e), CRC Press, 2018.
2. Iqbal Hussein, *Electric and Hybrid Vehicles-Design Fundamentals*, (2e), CRC Press, 2010.
3. Gianfranco Pistoia, *Electric and Hybrid Vehicles - Power Sources, Models, Sustainability, Infrastructure, and the Market*, (1e), Elsevier, 2010
4. Gianfranco Pistoia," *Behaviour of Lithium ion batteries in Electric Vehicles: Battery Health, Performance, Safety, Cost*", (1e), Springer, 2018.

MTE 4053: MECHATRONICS MODELLING OF HYBRID VEHICLES [2 1 0 3]

Introduction to Vehicle Propulsion and Powertrain Technologies: Objectives of vehicle propulsion control. Powertrain architecture and technologies. Importance of Powertrain Modeling and Models – Drivetrain. Engine Management systems (EMS): Basic engine operation- EMS building block, Effective work, Engine control structure and components, Automatic Code Generation and Information Exchange - Calibration and Parameter Representation - Engine Maps - Model-Based Development. Fuel management and control: Stoichiometry and air-fuel ratio – Engine concepts and its geometry, Engine control – Power, torque and mean effective pressure - Feed-forward and Feedback Control Structure, Fuel Dynamics and Injector Compensation Driveline modeling Driveline control: General Modeling Methodology - Graphical Scheme of a Driveline - A Basic Complete Model and Rigid Driveline - Reflected Mass and Inertias - Modeling of Neutral Gear and Open Clutch -Torque Converter - Control Design and Validating Simulations- Driveline control – goals of driveline control – State-space formulation – Controller formulation – Driveline control with LQG/LTR. Miscellaneous -Vehicle control systems and performance measures: ABS control systems –ABS cycle detection – control of the Yaw dynamics – derivation of simplified control law – derivation of reference values

References:

1. Lars Eriksson, Lars Nielsen, *Modeling and Control of Engines and Drivelines*, (1e), Wiley, 2014.
2. Georg Rill, *Road Vehicle Dynamics: Fundamentals and Modeling*, CRC press- Taylor and Francis group, 2011.
3. Uwe Kiencke, Lars Nielsen**,** *Automotive Control Systems: For Engine, Driveline and Vehicle*, (2e), Springer, 2005.
4. Rolf Isermann, *Engine Modeling and Control: Modeling and Electronic Management of Internal Combustion Engines*, Springer, 2014.

MTE 4063: BIG DATA ANALYTICS [2 1 0 3]

Big Data, Characteristics of Big Data, Data in a warehouse and data in Hadoop, Importance of Big Data, Big data use cases, Map Reduce, Distributed File System, Algorithms using Map Reduce, Communication Cost model, Complexity Theory, Meet Hadoop, Comparison with other systems, The Hadoop Distributed File System, Hadoop I/O, File Based Data structures, Developing a Map Reduce Application, Inverted Index for Text Retrieval, Graph Algorithms, Page Rank, Stream Data Model: A Datastream Management system, Sampling Data in a Stream, Filtering Streams, Distinct Elements in a Stream, NOSQL Models, Understanding Storage Architecture, Performing CURD operations, Querying NOSQL Stores.

References:

1. Anand Rajaraman and Jeffrey David Ullman, *Mining of Massive Datasets*, (1e) Cambridge University Press, 2011.
2. Tom White, *Hadoop: The definitive guide*, (3e), O'reilly, Yahoo Press, 2012.
3. Shashank Tiwari, *Professional NOSQL*, (2e), Wiley India Pvt. Ltd., 2012.
4. Jimmy Line, Chris Dyer, *Data Intensive Text Processing with MapReducee*, (1e), Mprgan and Claypool Publishers, 2010.
5. Paul C Zikopoulous, Chris Eaton, Dirk Deroos, Thomas Deutch, George Lapis, *Understanding Big Data*, (1e) McGraw Hill, 2012.

MTE 4064: BUILDING AUTOMATION [2 1 0 3]

Overview of Digital Controller: Data Form used in computers, Microcomputer, Input / Output Unit, Processor Operation and Software, Sensors, Actuator, I/O devices, Field Controllers. Network and Communication protocols: Networking basics, Types of Networks- Serial and Parallel Communication, RS232 and RS 485 Interfaces, MODBUS protocol overview, BACnet protocol overview. Introduction to Building Management Systems: Buildings and Energy Management, Different systems in a building. Introduction to HVAC, StruxureWare for Building Operation. General BMS architecture: Introduction to HVAC and Optimal control methods for HVAC Systems: Important components of HVAC, HVAC Control systems and Direct Digital Control, AHU, Chillers, Zones, Air Distribution Systems, Field Devices, Schneider Controllers (PLC's). Lighting control systems: Strategies for energy management and lighting. Security and Safety Control Systems: Access Control- Introduction, Basic Components, Controller / Panel, Credentials, Reader, Locking Device, How it works / Operations, Type of Card/Readers, Anti-Pass back, Power Requirements, Videos (Digital Video Recorder), Types of Camera, Fire Alarm Systems - Sprinklers. System integration and convergence: Need for integration, interoperability and protocols, BMS integration case studies, iBMS, Compatibility of different internet technologies and its application in BMS. Application of internet for Automation and Management: Web Based Automation, General Architecture, Web Enablement, Data Communication Energy Management: Overview on EMS, Energy Analysis/Audit. Green Buildings (LEED): Green Buildings Approach, Benefits of Green Buildings, Elements of Green Building Design, Leadership in Energy and Environmental Design (LEED), LEED Case Study.

References:

1. V. K. Jain , *Automation Systems in Smart and Green Buildings,* published by Khanna Publishers, 2009.
2. Reinhold A, *Understanding Building Automation Systems: Direct Digital Control, Energy Management, Life Safety, Security/access Control, Lighting, Building Management Programs,*

2009.
3. Ronnie J. Auvil , *HVAC Control Systems* , (2e), 2007.
4. Thomas L. Norman, *Integrated Security Systems Design: Concepts, Specifications, and Implementation* (1e) by CPP PSP CSC 2007.
5. Benantar, Messaoud, *Access Control Systems: Security, Identity Management and Trust Models*, Springer publication, 2005.

MTE 4065: COMPUTER ARCHITECTURE AND REAL TIME SYSTEMS [2 1 0 3]

Organization and Architecture, Processor Organization, The Instruction Cycle, Introduction to Parallel processing, Parallel Computer Structures, Architectural Classification schemes, Pipelining, Instruction Level Parallelism, SIMD Computer Organizations,SIMD Interconnection networks, Parallel Algorithms for Array processors, Symmetric Multiprocessor Organization, Cache Coherence and the MESI protocol, Multithreading and Chip Multiprocessors, Synchronization, Models of Memory Consistency, Clusters, Operation System Design Issues, Cluster Computer Architecture, Blade servers, Clusters compared to SMP, Multicore computers, Hardware Performance issues: Increase in Parallelism, Power consumption, Software performance issues: Software on multicore, Multicore organization, Intel x86 Multicore organization: Intel Core Duo, Intel Core i7.

References:

1. William Stalling, *Computer Organization and Architecture: Designing for Performance*, (8e), Pearson Prentice Hall, 2010.
2. Kai Hwan and Faye A. Briggs, *Computer Architecture and Parallel Processing*, TMH Private Ltd., 2012.
3. John L. Hennessy and David A. Patterson, *Computer Architecture, A Quantitative Approach*, (5e), Morgan Kaufmann, 2014.
4. Rajiv Chopra, *Advanced Computer Architecture (A Practical Approach)*, S. Chand and Company Ltd. 2011.

MTE 4066: COMPUTER NETWORKS AND COMMUNICATION PROTOCOLS [3 0 0 3]

Introduction to reference models, data communication, network architecture, basics of OSI, and TCP/IP reference models. Transmission media, FDM, TDM and CDMA, Frame relay and ATM switching, ISDN, local area network protocols, IEEE standards for LAN. Data link layer design, functions and protocols, link layer, error detection and correction techniques, multiple access protocol, Ethernet, hubs and switches, PPP. Network layer, Transport layer: connectionless transport-UDP, FTP, Electronic Mail in the Internet, P2P file sharing, HTTP, quality of services: ATM, Differentiated services Model, flow identification, scheduling, factors affecting QOS

parameters and service categories, network management, protocol, SNMP, CMIP, concept of traffic and service. Voice and video data, ATM Traffic, Traffic contracting.

References:

1. James F. Kurose, Keith W. Ross, *Computer Networking (A Top-Down Approach Featuring the Internet*, (3e), Pearson Education, 2005.
2. Andrew S. Tanenbaum, *Computer Networks*, (5e), PHI, 2010.
3. Charle Kaufman, Radia Perlman, Mike Specines, Uyless Black, *Computer Networks: Protocols Standards and Interfaces,* Prentice Hall of India Pvt. Ltd. 2010.
4. William Stallings, *Data and Computer Communications*, (7e), 2004, Prentice Hall of India Pvt. Ltd.

MTE 4067: DESIGN OF MECHANICAL DRIVES [2 1 0 3]

Introduction, bevel gear and worm gear, beam strength, dynamic load and wear load, heat dissipation and efficiency of worm gear, sliding contact bearings, lubricants, viscosity, bearing modulus, Sommerfield number, coefficient of friction, mechanism of film lubrication, eccentricity and minimum oil film thickness. Belt drives, power transmission, flat and V belts, power rating, V-flat drives, selection of belts and pulleys. Wire and rope drives - types & construction of wire ropes, loads & stresses in ropes, selection of wire ropes. Chain drives, chordal action, sprocket size and teeth, chain speed, selection of roller chains. Mechanical brakes - block brakes, band brakes, pivoted Shoe brakes, disc brake, torque capacity, heat dissipation, clutches, friction clutches, disc clutch, cone clutch, design projects.

References:

1. Shigley J. E. and Mischke C. R., *Mechanical Engineering Design, (5e),* McGraw Hill Inc, New York, 2004.
2. Bhandari V. B., *Design of Machine Elements, (2e),* Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
3. Norton R. L., *Machine Design - An Integrated Approach, (2e),* Prentice Hall Inc. New Jersy, 2004.
4. Juvenile R. C. and Marshek K. M., *Fundamentals of Machine Component Design, (3e),* John Wiley and Sons, Inc, New York, 2000.
5. Mahadevan K. and Balaveera Reddy K., *Machine Design Data Hand Book, (4e),* CBS Publishers and Distributors, New Delhi, 2014.

MTE 4068: DYNAMICS AND CONTROL OF MECHATRONICS SYSTEMS [3 0 0 3]

Industrial feedback controllers, PID controllers, tuning methods, frequency response approach, computational optimization, modified PID scheme. Introduction to state space analysis - state space representations, eigen vectors and eigen values, transfer functions, state space modeling. Control system design in state space, solution of LTI state equation, controllability and observability, state feedback controllers, state observers Lyapunov stability analysis, quadratic optimal control. Types of nonlinearity, describing functions phase plane method, linearization techniques, MATLAB simulation, state space modeling, feedback controllers, observers, regulator problems.

References:

1. Ogata K., *Modern Control Engineering,* (5e), Pearson Prentice Hall, 2005.
2. Karl J. Astrom, *Feedback systems- An Introduction for Scientists and Engineers*, Princeton University Press, 2008.
3. Norman S. Nise, *Control Systems Engineering*, (6e), John Wiley & Sons, Inc, 2011.
4. Stanley M. Shinners, *Modern Control Systems, Theory and Design*, John Wiley & Sons, Inc, 2009.
5. Gopal M., *Modern Control System Theory*, (2e), New Age International Ltd, 2005.

MTE 4069: ELECTRIC VEHICLE MACHINES AND DRIVES [3 0 0 3]

Overview of EV Technologies-Motor Drive Technology, Energy Source Technology, Battery Charging Technology, Vehicle-to-Grid Technology, Pure Electric Vehicle, Hybrid Electric Vehicle, Gridable Hybrid Electric Vehicle, Fuel-Cell Electric Vehicle. DC Motor Drives - System Configurations, DC Machines, DC–DC Converters, Soft-Switching DC–DC Converter Topologies, DC Motor Control, Regenerative Braking, Design Criteria of DC Motor Drives for EVs. Induction Motor Drives- System Configurations, Induction Machines, Inverters for Induction Motors, Induction Motor Control, Design Criteria of Induction Motor Drives for EVs. Permanent Magnet Brushless Motor Drives- System Configurations, PM Brushless Machines, PM Brushless Motor Control, Design Criteria of PM Brushless Motor Drives for EVs, Switched Reluctance Motor Drives- SRM Machines, SR Converters, Comparison of SR Converters for EVs, SR Motor Control, Design Criteria of SR Motor Drives for EVs, Machine Initialization, Planetary-Geared SR Motor Drive, Outer-Rotor In-Wheel SR Motor Drive. Integrated-Starter-Generator Systems - System Configurations, ISG Machines, ISG Operations, Cranking, Electricity Generation, Idle Stop-Start, Power Assistance. Planetary-Geared Electric Variable Transmission Systems: Input-Split PG EVT Systems, Compound-Split PG EVT Systems, Design Criteria of PG EVT Systems, PM Synchronous PG EVT System Configuration. Double-Rotor Electric Variable Transmission Systems- Double-Rotor Machines, Basic Double-Rotor EVT Systems, Advanced Double-Rotor

EVT Systems, Axial-Flux DR EVT System, Magnetless DR EVT System, Design Criteria of DR EVT Systems, Design Example of DR EVT Systems. Potential Applications of DR EVT Systems in HEVs.

References:

1. K T Chau, *Electric Vehicle Machines and Drives- Design, Analysis And Application*, (1e) John Wiley & Sons, 2015.

MTE 4070: EMBEDDED SYSTEMS AND RTOS [2 1 0 3]

Introduction to embedded system, attributes and major application areas of ES, Processor and memory organization, Communication networks, ARM processor introduction, architectural inheritance, Architectural features of ARM Processor, instruction set, Pipelined architecture in ARM, THUMB instruction format, memory mapped peripherals, architectural features of ARM Cortex M3 and programming examples. Introduction To Real-Time Operating Systems, Tasks and Task states, Semaphores, Message queues, Mail boxes and pipes, Hard and Soft real time systems, scheduling considerations, Multicore real time systems. Case studies.

References:

1. Wolf, Wayne, *Computers as Components- Principles of Embedded Computing System Design*, Morgan-Kaufmann, 2000.
2. Steve Furber, *ARM System-on-chip Architecture*, Pearson Education, 2000.
3. Andrew Sloss, Domnic Symes, Chris Wright, *ARM system Developer's Guide*, 1st edition.

MTE 4071: ENGINEERING MATERIALS [3 0 0 3]

Crystal structures, Miller indices, crystal imperfections, mechanism of solidification, nucleation and crystal growth, phases in solids, equilibrium diagrams, iron-Carbon systems, principle and objectives of heat treatment, TTT diagrams, electronic materials, deposition of thin films, insulators and dielectric properties, polarization in dielectrics, electrostriction, piezoelectricity, ferroelectricity, magnetic materials, magnetic dipole and moments, magnetization, super paramagnetic materials, applications of magnetic materials, photonic materials, refraction, reflection, absorption, emission phenomena.

References:

1. Donald R. Askeland and Pradeep P. Fulay, *The Science and Engineering of Materials*, Cengage learning publishers,*(6e)*,2011.
2. Lakhtin Yu., *Engineering Physical metallurgy and heat treatment*, MIR Publishers, Moscow, 1985.

3. Higgins R.A., *Engineering Metallurgy, (5e),* ELBS, London,1983.
4. Avner S.H., *Introduction to Physical Metallurgy, (3e),* McGraw Hill. Delhi, 2004.
5. Arzamasov, *Material Science,* MIR Publishers, Moscow. 1989.

MTE 4073: MACHINE LEARNING [2 1 0 3]

Introduction to Machine Learning, Review of Linear Algebra, Review of Probability theory, Overview of Convex optimization, Hidden Markov models, Multivariate Gaussian distribution, Gaussian Processes. Bayesian decision theory, Maximum likelihood ratio, Parametric classification, Regression, Multivariate methods, K-nearest neighbor classification, Supervised learning: Setup, LMS, Logistic regression, Perceptron, Exponential family, Generative learning algorithms, Gaussian discriminant analysis, Naïve Bayes, Support vector machines, Model selection and feature selection, Evaluation and debugging learning algorithms. Unsupervised learning: Clustering, K-means, Hierarchical clustering, Competitive learning, Radial basis functions. EM, Mixture of Gaussians, Factor analysis, Principal Component Analysis, Independent Component Analysis, Naïve Bayes classifier, Hidden Markov model, Linear Regression, Belief Propagation, Generating diverse learners, Voting, Error correction output codes, Bagging, Boosting. Applications of Machine Learning in Robotics: Developmental Robotics, Cognitive Robotics, Evolutionary Robotics.

References:

1. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*, (1e), MIT Press, 2012.
2. Ethem Alpaydin, *Introduction to Machine Learning*, (2e), MIT Press, 2010.
3. Mehryar Mohri, Afshin Rostamizadeh and Amet Talwalkar, *Foundation of Machine Learning*, (1e), MIT Press 2012.
4. Daphne Koller and Nir Friedman, *Probabilistic Graphical Models: Principles and Techniques*, (1e), MIT Press, 2009.
5. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, (1e), Springer, 2007.

MTE 4074: MACHINE TOOL TECHNOLOGY [3 0 0 3]

Types of motion in cutting, cutting speed, feed, depths of cut in machining, cutting tools classification, nomenclature of single point cutting tool, difference between orthogonal and oblique cutting, mechanism of metal cutting, types of chips, chip breakers, forces acting on a tool, merchant circle diagram, velocity relations, specific energy in cutting, tool wear, tool life factors, Taylor's tool life equation, tool wear mechanisms, heat distribution in metal cutting, measurement of temperature in metal cutting, lathe tool dynamometer, cutting fluids selection and applications, cutting tool materials, specifications for inserts and tool holders. CNC tooling, tool presetting, automated tool & pallet changing, work holding, cutting process parameter selection, jigs and fixtures, types of clamping devices, principles of clamping.

References:

1. Milton C.Shaw, *Metal Cutting Principles, (2e)*, Oxford University Press, 2000.
2. Kempster, *Jigs and Fixtures, (3e)*, Mark Howard Publications, 2004.
3. Steve Krar, Arthur Gill and Peter Smid, *Machine Tool Technology Basics, (2e)*, Industrial Press Inc., U.S, 2012.
4. Sharma. P. C, *A Text Book of Production Engineering, (7e)*, SChand Publishers, New Delhi, 2008.

MTE 4075: MACHINE VISION AND IMAGE PROCESSING [3 0 0 3]

Image Acquisition and Analysis: Vision system components, Image acquisition and analysis, Image digitization, Image enhancement, restoration, Segmentation, Morphological Operations, image representation and analysis, color image processing. 3D Vision: Camera and optics, Perspective Projection Geometry Rotation and translation matrix, Pinhole camera model, Calibration methods, Intrinsic and Extrinsic Camera Parameters, Stereovision, Stereo correspondence Algorithms, Epipolar Geometry, Essential and fundamental matrix, 3D Reconstruction. Motion Estimation and Tracking: Optical flow estimation, Object tracking with Kalman filtering. Basic idea of localization employing passive markers. Case Studies/Application: Basic color detection, Face recognition, Vehicle tracking, applications using computer vision toolbox and image processing toolbox of MATLAB.

References:

1. Rafael C. Gonzalez, Richard E. Woods, *Digital Image Processing*, (3e), Pearson Education, 2008.
2. Milan Sonka, Vaclav Hlavac, Roger Boyle, *Image Processing, Analysis and Machine Vision*, (2e), 1998.
3. Boguslaw Cyganek & J. Paul Siebert, *An Introduction to 3D Computer Vision Techniques and Algorithms*, (1e), Wiley, 2009
4. David A. Forsyth, Jean Ponce, *Computer vision: A modern approach*, Pearson Education Limited.
5. E.R. Davies, Royal Holloway, *Machine Vision: Theory, Algorithms and Practicalities*, (3e), University of London, 2004.

5. Juneja and Nitin Seth, *Fundamental of Metal Cutting and Machine Tools, (2e)*, New Age International Publishers, 2003.

MTE 4076: MECHANICAL VIBRATIONS [2 1 0 3]

Introduction to mechanical vibration, vibration system and types, vibration analysis - degrees of freedom, mathematical modeling, equations of motion, SHM, natural frequency of single degree of freedom system – mathematical modeling, derivation of governing differential equation of motion for free undamped and damped systems, forced vibration – single degree of freedom system under harmonic excitation, steady state, reciprocating and rotating unbalance, transmissibility and isolation, base excitation with harmonic input. Two degree of freedom systems - natural frequencies and mode shapes, forced vibration. Natural frequency of multi-degree of freedom systems, vibration control, vibration testing and measurement.

References:

1. Groover G.K., *Mechanical Vibrations*, Nemchand and Bros, Roorkee, 2012.
2. Singirisu Rao S, *Mechanical Vibration*, Pearson Education, Delhi, 2004.
3. Dukkapatti Rao V., *Text Book of Mechanical Vibration*. Prentice Hall of India Ltd, 2004.
4. Daniel Imnan J. *Engineering Vibration*, Prentice Hall, New Delhi, 2001.
5. Thomson W.T., *Theory of Vibrations with Applications*, Chapman and Hall, 4th Edition, 1993.

MTE 4077: MICRO ELECTRO MECHANICAL SYSTEMS [2 1 0 3]

Introduction to MEMS and microsystems - products, evolution of micro-fabrication, microelectronics, miniaturization, applications in automotive and other industries, micro sensors, micro actuation, micro accelerometers, microfluidics. Scaling laws in miniaturization, scaling laws – geometry, electrostatic forces, electromagnetic forces, electricity, heat transfer and fluid mechanics. Materials for MEMS and microsystems. Microsystems fabrication processes, photo lithography, ion implantation, diffusion, oxidation, chemical vapor deposition, physical vapor deposition, deposition by epitaxy, etching, bulk manufacturing, surface micromachining, LIGA process. Microsystems – design and packaging, mechanical packaging of microelectronics, assembly of microsystems, packaging materials.

References:

1. Tai Ran Hsu, *MEMS and Microsystems - Design and Manufacturing*, Tata McGraw Hill, 2010.
2. Marc J. Madou, *Fundamentals of Micro Fabrication - The Science of Miniaturization*, CRC Press, 2002.
3. Wolfgang Menz, J. Mohr and Oliver Paul, *Microsystem Technology*, Wiley-VCH, 2001.
4. Mohamed Gad-el-Hak, *The MEMS Handbook*, CRC Press 2002.
5. S.D. Senturia, *Microsystem Design*, Kluwer Academic Publishers, 2001.

MTE 4078: MICRO - MANUFACTURING SYSTEMS [3 0 0 3]

Introduction, working principles and process parameters, machine tools, applications of the micro manufacturing processes, challenges in meso, micro, and nanomanufacturing, industrial applications and future scope of micro-manufacturing processes. Different instruments related to micro manufacturing such as microsensors, microactuators, microsystems. Working principles, machine construction, and applications of micromachining, nanofinishing, microjoining, microforming, microcasting, micromolding, LIGA for micro/nano products and features, the diversified industrial applications of the micro-manufactured processes, and recent research trends in this area.

References:

1. Jain V. K., *Introduction to Micromachining,* Narosa Publishing house Pvt. Ltd., 2010.
2. Jain V. K., *Micromanufacturing,* CRC Press, 2012.
3. Jain V. K., *Advanced Machining Processes,* Allied Publishers Pvt. Ltd., 2014.
4. Mahalik N. P., *Micromanufacturing & Nanotechnology*, Springer Berlin Heidelberg, 2006.
5. Jackson J. M., *Microfacbrication & Nanomanufacturing*, CRC Press, 2005.

MTE 4079: NANOTECHNOLOGY [3 0 0 3]

Introduction to nanotechnology, bottom-up and top-down approaches, physical and chemical properties, methods of preparation of nanoparticles, carbon nanostructures and their applications, physical chemistry of nanosystems, micro electro mechanical devices and technologies - microsensors, MEMS fabrication processes and applications, microscale and nanoscale heat conduction, nanofluids preparation and characterization, nanomaterials used in energy and environmental applications and their properties, future development of micro actuators, nano-lithograghy, photoresist patterning, photolithography, electron beam lithography, production of polygon mirrors, optic fibers, future trends in nanotechnology.

References:

1. Charles P. Poole, *Introduction to Nanotechnology*, Wiley-Interscience, 2003.
2. Guozhong Cao, *Nanostructures & Nanomaterials*, Imperial College Press, 2004.
3. C B Sobhan, *Microscale and Nanoscale Heat Transfer*, Taylor and Francis, 2008.
4. Norio Taniguchi, *Nanotechnology,* Oxford University Press, 2008.
5. James J Allen, *MEMS Design,* Taylor and Francis, 2005.

MTE 4080: PRODUCTION AND OPERATIONS MANAGEMENT [2 1 0 3]

Introduction, production consumption cycle, forecasting- quantitative and qualitative methods, Forecast control, measures of forecast accuracy product development and design, product life cycle, process design, process charts, flow diagrams and man machine charts capacity planning, breakeven analysis, single and multi-product P-V charts, aggregate planning, trial and error approach, use of transportation algorithm, job shop scheduling, Sequencing of "n" jobs through 2 machines, "n" jobs through 3 machines and 2 jobs through "n" machines inventory management and line balancing, resource conversion and concepts, planning models and behavioural applications, case studies.

References:

1. Adam Everett E. Jr. and Ebert Ronald J., *Production and Operations Management*, Prentice Hall of India Pvt. Ltd., 2002.
2. Chase Richard B., Aquilano Nicholas J. and Jacobs F. Roberts, *Production and Operations Management,* Tata McGraw-Hill publishing Co. Ltd., 1999.
3. Eilon Samuel, *Elements of Production Planning and Control,* Universal Publishing Corporation, 1991.
4. Monks Joseph G., *Operations Management*, Tata McGraw-Hill Publishing Co. Ltd., 2004.
5. Krajewski Lee J. and Ritzman Larry P., *Operations Management*, Pearson Education Pvt. Ltd., 2005.

MTE 4081: ROBOTICS II [2 1 0 3]

Autonomous mobile robots-: Introduction, locomotion legged mobile robots. Wheeled locomotion. Robot kinematics models & constraints, Mobile robot maneuverability. Mobile robot workspace-degree of freedom, Homonymic robots, path & trajectory considerations. Motion control - open loop control Feedback control. Robot control problems, controllers -PD, PID compensation, closed loop control, gain tuning, performance analysis, simulation analysis. Set point Tracking. Nonlinear dynamics and control – Lyapunov stability theorem, Robust control, Feedback-Linearization Controllers, Lyapunov Designs, Variable-Structure Controllers, Saturation-Type Controllers. Inverse dynamics controllers, Force control, stiffness control, Impedance control, Hybrid Position/Force Control, Reduced state modeling and control. Modeling soft mechanics (numerical, computational, analytical): Hyper-redundant kinematic structures, Resolution of inverse kinematics, Mathematical formulation for animating flexible structure, Bio-mimitics, Continuum Mechanics, Eigenvalues and Eigenvectors, Geometric interpretation of eigenvectors, Cayley-Hamilton theorem, Principal Component Analysis, Singular Value Decomposition, ISO-Map Dimensional Reduction technique. Sensors and Actuators: Soft Actuators, Soft Sensors,

Electroactive Polymer, Ionic Polymer Metal Composites, Shape Memory Alloy, Artificial Muscles based on Electric/Pneumatics, Thermal/Chemical Actuation

References:

1. Jog, C.S., *Foundations and applications of mechanics: Volume I: Continuum mechanics*, 2007, Narosa Publishing House.
2. Alexander Verl, Alin Albu-Schaffer, Oliver Brock, Annika Raatz, *Soft Robotics Transferring Theory to Application*, Springer, 2015.
3. Jaeyoun (Jay) Kim , *Microscale Soft Robotics: Motivations, Progress, and Outlook*, Springer International Publishing, 2017.
4. Cecilia Laschi, Jonathan Rossiter, Fumiya Iida, Matteo Cianchetti, Laura Margheri, *Soft Robotics: Trends, Applications and Challenges*, Springer International Publishing, 2016.
5. Fahimi, Farbod. *Autonomous robots: modeling, path planning, and control*. Vol. 107. Springer Science & Business Media, 2008.

MTE 4082: SYSTEMS MODELING AND SIMULATION [3 0 0 3]

Principles of modeling and simulation, modeling and simulation of mixed systems, transfer function, block diagram, state space representation of SISO, MIMO, modeling of dynamic systems, construction, analysis, practical applications, linear systems, methods of model order determination, impulse and frequency response methods, system identification, algorithms for parameter estimation, gradient algorithm, least square algorithm, ARX, ARMAX applications of LS and ARMA methods, regression methods, introduction to nonlinear modeling, identification NARMAX model, case studies UAV quad-rotor, hard discs, maglev systems, ball and beam systems.

References:

1. George Pelz, *Mechatronic Systems Modeling and Simulation with HDLs*, Wiley, 2003.
2. Devdas Shetty, Richard Kolk, *Mechatronics System Design, (2e)*, Cengage Learning, 2010.
3. Benjamin C. Kuo, Farid Golnarghi, *Automatic Control Systems, (8e)*, Wiley, 2009.
4. Jack W. Lewis, *Modeling of Engineering Systems PC-Based Techniques and Design Tools*, High Text Publications, 2000.
5. Ioan D. Landau, Gianluca Zito, *Digital Control Systems Design, Identification and Implementation*, Springer, 2006.

MTE 4083: WIRELESS SENSOR NETWORKS [3 0 0 3]

Challenges for wireless sensor networks, single node architecture, hardware components, energy consumption of sensor nodes, network architecture, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, wireless channel and communication fundamentals, frequency allocation, modulation and demodulation, MAC protocols, contention-based protocols, SMAC – BMAC, TRAMA, IEEE 802.15.4 MAC protocol, Q-MAC (Querry MAC), Q-MAC (QoS MAC). Routing challenges and design, SPIN COUGAR, ACQUIRE, LEACH, PEGASIS, GF, GAF, GEAR, Aggregation techniques – TAG, Tiny DB traditional transport control protocols. Wireless LANs: 802.11, 802.11a/b/g, 802.16-WiMAX, UWB communications, wireless personal area networks, BlueTooth. Healthcare monitoring system using wireless sensor networks, remote home lighting and appliance control system, automatic speed control and vehicle tracking using GSM and GPS technologies.

References:

1. Kazem Sohraby, Daniel Minoli and Taieb Znati, *Wireless Sensor Networks Technology-Protocols and Applications,* John Wiley & Sons, 2007.
2. Holger Karl and Andreas Willig, *Protocols and Architectures for Wireless Sensor Networks,* John Wiley & Sons, Ltd, 2005.
3. Ananthram Swami, Qing Zhao, Yao-Win Hong, Lang Tong Pub, *Wireless Sensor Networks Signal Processing and Communications*, John Wiley & Sons.
4. Murthy, *Ad Hoc Wireless Networks: Architectures and Protocols*, Pearson Education.
5. Sridhar S. Iyengar, NandanParameshwaran, Vir V. Phoha, N. Balakrishnan, Chuka D. Okoye, *Fundamentals of Sensor Network Programming: Applications and Technology*, John Wiley & Sons

OPEN ELECTIVES

MTE 4301: AUTONOMOUS ROBOTS [2 1 0 3]

Locomotion, Legged Mobile Robots, Leg configurations and stability, Examples of legged robot locomotion, Wheeled Mobile Robots, Wheeled locomotion, Mobile Robot Kinematics: Kinematic Models and Constraints, Representing robot position, Forward kinematic models, Wheel kinematic, Robot kinematic constraints, Examples. Perception: Sensors for Mobile Robots, Sensor classification, Characterizing sensor performance, Wheel/motor sensors, Heading sensors, Ground-based beacons, Active ranging, Motion/speed sensors, Vision-based sensors. Mobile Robot Localization: The Challenge of Localization: Noise and Aliasing, Sensor noise, Sensor aliasing, To Localize or Not to Localize: Localization-Based Navigation versus Programmed

Solutions, Map Representation, Continuous representations, Decomposition strategies, Probabilistic Map-Based Localization, Markov localization, Kalman filter localization. Planning and Navigation: Competences for Navigation: Planning and Reacting, Path planning, Obstacle avoidance.

References:

1. Roland Siegwart, Illah R. Nourbaksh , *Introduction to Autonomous Robots*, MIT Press, 2004.
2. Howie Choset, Kevin M Lynch, *Principles of Robot Motion*, MIT Press, 2005
3. King Sun Fu, Gonzalez , *Robotics- control, sensing, vision, and intelligence*, McGraw-Hill, 1987.

MTE 4302: ELECTRIC VEHICLE TECHNOLOGY [3 0 0 3]

Vehicle dynamics-vehicle resistance, dynamic equation, tire ground adhesion, maximum tractive effort, vehicle speed, transmission characteristics, vehicle performance, hybrid and electric drive trains-configurations of electric vehicles, traction motor characteristics, basic concept of hybrid traction, hybrid drive train architecture – series, parallel torque and speed coupling, electric propulsion unit, different motors, configuration and control of dc motor drives, introduction to power modulators, control and regenerative breaking, classification of different energy management strategies, fundamentals of regenerative braking, sizing the drive system- propulsion motor, sizing the power electronics, selecting the energy storage technology, communications, supporting subsystems, design of series hybrid drive train.

References:

1. Mehrdad Ehsani, Modern Electric, *Hybrid Electric and Fuel Cell Vehicles- Fundamentals, Theory and Design*, (2e), CRC Press, 2010.
2. Iqbal Hussein, *Electric and Hybrid Vehicles-Design Fundamentals*, (2e), CRC Press, 2010.
3. Gianfranco Pistoia, *Electric and Hybrid Vehicles - Power Sources, Models, Sustainability, Infrastructure and the Market*, (1e), Elsevier, 2010.

MTE 4303: HYDRAULICS AND PNEUMATICS SYSTEMS [2 1 0 3]

Pneumatic systems, structure and signal flow, compressors, actuators and control valves, single acting and double acting cylinders, manual pneumatics, single and multiple actuators, limit switches, proximity sensors, electro pneumatics and design of electro pneumatic circuits, direction control valves, relay control systems, timers, counters, pressure control valves, closed loop pneumatics and Flow control valves. Hydraulic systems, physical principles of oil hydraulics, hydraulic actuators, valves and accessories, hydraulic power pack, types of hydraulic pumps,

accumulator, Filters, hydraulic circuits, regenerative, meter in, meter out, bleed off, sequencing, pressure reducing circuits, electro hydraulic circuits, proportional hydraulics and servo hydraulics.

References:

1. Anthony Esposito, *Fluid power with applications*, Pearson Education, 2003.
2. Andrew A. Parr, *Hydraulics and Pneumatics*, Elsevier Science & Technology Books, 1999.
3. Scholz D., *Proportional Hydraulics*, Festo Didactic GMBH & Co, Germany, 2002.
4. Majumdar S.R., *Pneumatic Systems - Principles and Maintenance*, Tata McGraw Hill, 2000. Merkle D., Rupp K. and Scholz D., *Electrohydraulics Basic Level TP 601*, Festo Didactic GMBH & Co, Germany, 1994.

MTE 4304: INDUSTRIAL IoT [2 1 0 3]

Introduction to Industrial IoT, Components of IIoT. Sensors, Acceleration: Accelerometers (Piezoelectric, Capacitive); Proximity & Range: Proximity Switches, Ultrasonic Sensor, Hall Effect Sensor, Eddy Current Sensor, Temperature: Bimetallic, RTD, Thermocouple, Thermistor, Optical Pyrometer; Pressure: Electric Transducers, Pressure Transmitters, Pressure Gauges – McLeod, Knudsen, Pirani, Vacuum; Flow: Ultrasonic, V Cone, Laser Doppler, Mass flowmeters. Introduction to PLC: Advantage of PLC, and Chronological Evolution of a PLC, Type of PLC, Parts of PLC and Block diagram PLC, I/O modules and interfacing, networking of PLC ,Input-Output System Sinking and Sourcing, power supply module, Programming Equipments. Programming formats using contacts and coils, latching etc. Converting simple relay logic diagram to PLC ladder diagram, Digital logic implementation in ladder programming, Timer and counter functions, Arithmetic functions, R-trig / F- trig pulses, shift registers, sequence functions, PID principles and functional block, position indicator with PID control. Industrial Process Automation, Networks and Protocols: AS-i, CAN, DeviceNet, Interbus, LON, Foundation Fieldbus, HART, PROFIBUS-PA, BACnet, ControlNet, IndustrialEthernet, Ethernet/IP, MODBUS, PROFIBUS-DP. Database-System Applications, Purpose of Database Systems, View of Data, Database Languages, Relational Databases. Introduction to security, Characteristics of Information, Components of an Information system, Security System Development Lifecycle, The Need for Security- Business Needs first, Threats, Attacks, Intruders, Intrusion detection.

References:

1. Liptak, B.G. (Ed.), *Instrument engineers' handbook, Vol. 3: Process software and digital networks*, (1e), CRC Press, Boca Raton, London, 2002.
2. Silberschatz, Korth, Sudarshan, *Database System Concepts*, (6e), McGraw Hill, New York, 2011.

3. William Stallings, *Cryptography and Network Security: Principles and Practice*, (5e), Prentice Hall, 2010.

MTE 4305: INTRODUCTION TO ROBOTICS [2 1 0 3]

Introduction: Definition of robots, definition and factors affecting the control resolution, spatial resolution, accuracy and repeatability, specification of a robot, actuators and sensors, drives and transmission systems used in robotics. Spatial descriptions and transformations: Descriptions, operators, transform equations. Introduction to Lie algebra and Rodrigues's rotation formula and Quaternions. Manipulator kinematics: Link description, manipulator kinematics, actuator space, joint space, and Cartesian space, kinematics of two industrial robots, frames with standard names. Introduction to kinematics of parallel manipulators, Closed loop constraints, four bar mechanism, Stewart platform. Inverse manipulator kinematics: Pieper's solution when three axes intersect. Manipulator dynamics: Introduction, acceleration of a rigid body, mass distribution, Newton's equation, Euler's equation iterative Newton-Euler dynamic formulation. Trajectory generation: Path description and generation, joint-space schemes Cartesian-space schemes. Linear control of manipulators: Introduction, feedback and closed-loop control, second-order linear systems, control of second-order systems, trajectory-following control, continuous vs. discrete time control, modeling and control of a single joint.

References:

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, (3e), PHI, 2005.
2. C. Peter. *Robotics, Vision and Control: Fundamental Algorithms in MATLAB*. Vol. 73. Springer, 2011.
3. G. Ashitava, *Robotics: Fundamental Concepts and Analysis*, Oxford University Press, 2006.
4. Murray, Richard M., Zexiang Li, S. Shankar Sastry, and S. Shankara Sastry, *A Mathematical Introduction to Robotic Manipulation*, CRC press, 1994.
5. S. Bruno and O. Khatib, *EDS: Springer handbook of Robotics*, Springer, 2016.

MTE 4306: MECHATRONICS SYSTEMS [2 1 0 3]

Mechatronic Engineering: Introduction, Mechatronic Systems, Modelling, and Design - Coupled Design, Mechatronic Design Quotient, Design Evolution, Evolution of Mechatronics, Application Areas. Basic Elements and Components: Mechanical Elements: Mass, Spring, and Damper. Fluid Elements: Fluid Capacitor, resistor. Thermal Elements: Thermal capacitor, and resistor. Mechanical Components: transmission, lead screw and nut, and harmonic drives. Passive Electrical Elements and Materials, Active Electronic Components, Light Emitters and Displays and Light Sensors. Modelling of Mechatronic Systems: Dynamic Systems and Models, Transfer Functions and Frequency-Domain Models, Equivalent Circuits and Linear Graph Reduction, Block

Diagrams, Response Analysis, Computer Simulation. Signal Conditioning: Impedance Characteristics, Amplifiers, filters, Modulators and Demodulators, Analog-to-Digital Conversion. Sensors and Actuators: Potentiometer, Resolver, Encoders, Proximity Sensors, Tactile Sensors.Hydraulic, Pneumatic and Electrical Actuators. Microcontrollers: Microcontroller Architecture, Input / Output Hardware, and Programming. Case Studies in Mechatronics Robotics Case Study, Hydraulics Based Case Study, Electrical Based Case Study, Pneumatics Based Case Study.

References:

1. Clarence W. de Silva, *Mechatronics: A Foundation Course*, CRC Press, 2010.
2. Ganesh S. Hegde, *Mechatronics*, Laxmi Publications Pvt Ltd., 2011.