M. Tech. in Robotics

Brief Description: M.Tech. in Robotics is an interdisciplinary Masters Programme composed of five basic disciplines namely Mechanical Engineering, Electronics Engineering, Electrical Engineering, Computer science and Engineering, and Instrumentation Engineering. There is a growing demand for students specialised in this area in Indian industries, defence applications, atomic energy, space research, medical research etc. Hence this degree would help in generating trained and qualified manpower in this area.

Eligibility:

1. The eligibility for the M.Tech. in Robotics will be B.E./B.Tech degree or AMIE in Mechanical/Electronics/Electrical/Computer Science & Engineering/Instrumentation Engineering disciplines from recognized university.
2. This programme is open for civilian GATE qualified candidates, DRDO Scientists/Officers and Officers from Tri-services. This programme is also open to foreign nationals from the countries approved by GOI.

Organization: M. Tech in Robotics is a four-semester master's programme. There are six compulsory courses & a laboratory in the first semester, two compulsory and four electives in the second semester and two electives in the third semester. In each semester, a mid semester examination and an end semester examination will be conducted in addition to continuous evaluation for each course. M.Tech dissertation first phase evaluation is done by a committee duly constituted by Chairman, PGC at the end of third semester. At the end of the final semester, student submits a thesis and makes a presentation about the project, which is evaluated by duly constituted committee constituted by Controller of Examinations, DIAT (DU), Pune.

The details of the courses offered under the programme are given below:

Semester I

Sl. No.	Proposed Course Code	Course	Contact Hours/week		Credits
			L	T/P	
1	AM 607	Mathematics for Engineers	3	0	3
2	CE 696	Artificial Intelligence and Expert Systems	3	0	3
3	EE 666	Introduction to Electronic Systems	3	0	3
4	EE 664	Inertial Sensors and Systems	3	0	3
5	ME 626	Introduction to Robotics	3	0	3
6	ME 627	Mechatronics	3	0	3
7	ME 633	Robotics Lab	0	4	2
		Total	**18**	**4**	**20**

Semester II

Sl. No.	Proposed Course Code	Course	Contact hours/week		Credits
			L	T/P	
1	AE 619	Robotic Control	3	0	3
2	ME 628	Robot Kinematics and Dynamics	3	0	3
3		Elective – I	3	0	3
4		Elective – II	3	0	3
5	EE 667	Microcontrollers and Embedded systems	3	0	3
6	ME 638	Field & Service Robots	3	0	3
7	TM 649	Scientific/Engg.Practices and Skills	3	0	3
		Total	**21**	**0**	**21**

***Practice school (optional) of 4 weeks during summer vacation**

Semester III

Sl. No.	Proposed Course Code	Course	Contact Hours /week		Credits
			L	T/P	
1		Elective – III	3	0	3
2		Elective – IV	3	0	3
3	ME 651	M.Tech. Dissertation Phase I	16		8
		Total	**22**		**14**

Semester IV

Sl. No.	Proposed Course Code	Course	Contact Hours /week		Credits
			L	T/P	
1	ME 652	M.Tech. Dissertation Phase II	28		14
		Total	**28**		**14**

List of Electives

Sl. No.	Proposed Course Code	Course Name
1	AE 612	Nonlinear and Robust Control
2	AE 617	Introduction to UAVs
3	AM 625	Digital Image Processing
4	CE 691	Secure Wireless Sensor Network
5	CE 697	Robot Programming
6	CE 698	Computer Graphics
7	EE 604	Digital communication
8	EE 613	Electronics Warfare
9	EE 618	DSP System Design
10	EE 621	Digital Interface Design
11	ME 609	Mechanical Vibrations
12	ME 629	Industrial Automation
13	ME 635	CAD/CAM
14	ME 634	Flexible Manufacturing Systems
15	ME650	Mini Project Work
16	TM 609	Systems Engineering
17	AP 610	Nanotechnology
18	EE 607	Advanced Wireless Communication
19	EE 622	Inertial Naviagation System

AM 607 Mathematics for Engineers (SEM I) 3-0-3

Linear Algebra: General (real) vector spaces, Subspaces, Linear independence, Dimension, Norms, Orthogonal bases and Gram-Schmidt orthogonalization.

Principles of floating point computations and rounding errors.

Systems of Linear Equations: factorization methods, pivoting and scaling, residual error correction method.

Iterative methods: Jacobi, Gauss-Seidel methods with convergence analysis, Conjugate gradient methods.

Nonlinear systems: Newton and Newton like methods.

Interpolation: review of Lagrange interpolation techniques, Newton interpolation, piecewise linear, cubic splines and Bezier curves, error estimates.

Approximation: uniform approximation by polynomials, data fitting and least squares approximation.

Numerical differentiation and integration: Differentiation and integration by interpolation, adaptive quadratures and Gaussian quadrature.

Initial Value Problems for Ordinary Differential Equations: Euler, Modified Euler, Runge - Kutta methods, multi - step methods, predictor and corrector methods, stability and convergence analysis.

Two Point Boundary Value Problems: finite difference methods with convergence results.

Solution of PDE: Parabolic, Hyperbolic and Elliptic Equations using finite difference method.

Text/References

1. Linear Algebra and its Applications, 4th Ed., 2008, Gilbert Strang, Academic Press.
2. Applied Linear Algebra and Matrix Analysis, 2007, Thomas S Shores, Springer.
3. Numerical Analysis, 9th Ed., 2010, Richard L. Burden, J. Douglas Faires, Brooks/Cole.
4. An Introduction to Numerical Analysis, 2nd Ed. 2008, Kendall E. Atkinson, John Wiley & Sons.
5. Elementary Numerical Analysis - An Algorithm Approach, 3rd Ed, 2008, Samuel D Conte and Carl de Boor, McGraw Hill.
6. Numerical Methods for Scientific and Engineering Computation, 6th Ed., 2012, M. K. Jain, S.R.K. Iyengar, R.K. Jain, New Age International Ltd.

7. Numerical Solutions of Partial Differential Equations: An Introduction, 2nd Ed., 2005, K. W. Morton, D. F. Mayers, Cambridge University Press.
8. Scientific Computing and Differential Equations: An Introduction to Numerical Methods, 2nd Ed. 1992, Gene H. Golub, J. M. Ortega, Academic Press.
9. Numerical Computation in Science and Engineering, 2nd Ed., 2008, G. Pozrikidis, Oxford University Press.

CE 696 Artificial Intelligence and Expert Systems (SEM I) 3-0-3

Introduction to AI, Knowledge-based Intelligent Systems, Rule based Expert Systems**;**

Uncertainty Management in rule-based expert systems: Introduction to Uncertainty, Basic Probability Theory, Bayesian reasoning, Certainty Factors;

Fuzzy Expert Systems: Introduction to Fuzzy thinking, Linguistics variables and Hedges, Fuzzy Rules, Fuzzy Inference, Defuzzification ;

Learning: Overview of different forms of learning, Learning Decision Trees, Neural Networks, Natural Language Processing.

Artificial Neural Networks: Basics of Neuron, Perceptron, Multi-layer neural network, Hop-field network, Self-Organizing Neural Networks;

Evolutionary Computation: Genetic Algorithms, Evolution Strategies

Hybrid Intelligent Systems: Neuro-Fuzzy, ANFIS; Probabilities, Bayesian Networks.

Applications of AI in Robotics: Subsumption Robots, Subsumption Architecture, Strengths and Weaknesses of the Architecture. Sensors, vision camera etc. for perception and obstacle avoidance.

Text/References

1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice-Hall, Third Edition (2009)
2. E. Rich and K. Knight, Artificial Intelligence, 2nd ed., McGraw-Hill, New York, 1991.
3. M. Ginsberg, Essentials of Artificial Intelligence, Morgan Kaufmann, San Mateo, Ca., 1993.
4. D. Poole and A. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, Cambridge, UK, 2010.
5. P. H. Winston, Artificial Intelligence, 3rd ed., Addison-Wesley, Reading, Mass., 1992.

6. Brooks, Rodney (1999). Cambrian Intelligence: The Early History of the New AI. Cambridge, Massachusetts: The MIT Press. pp. 8–12;15–16. ISBN 0-262-02468-3.

EE xxx Introduction to Electronic Systems (SEM I) 3-0-3

Introduction:
Introduction to basic electronics devices – junction diode, BJT, amplifier, op-amps & instrumentation amplifier with mathematical operation. Number System: Introduction to binary, octal, decimal & hexadecimal systems. Introduction to Microprocessor and Microcontrollers, Power amplifiers – Class A, B, AB, C, Tuned amplifier. Different stages of Operational Amplifier: Differential Amplifier, Constant current source (current mirror etc.), Precision Rectifier.

Analog and Digital IC Design: Operational amplifiers - feedback-Filter Design-ADC-DAC. Analog IC Design Flow -Digital IC Design Flow- Bipolar and CMOS Technology, Combinational MOS logic circuits –static logic Synchronous system and Sequential circuits design.

Introduction to Digital communication and wireless communication
Elements of Digital communication and information theory, Waveform coding techniques, Digital multiplexing, Digital Baseband transmission, Digital modulation techniques, Introduction to wieless communication, Wireless-transmission, Spread spectrum modulation techniques, Wireless LAN, Mobile Network Layer, Mobile transport Layer, Support for Mobility.

Introduction to Digital signal processing and image processing.
Introducation, Frequency domain representation of discrete time signal and systems, Processing of continuous time signals, Discrete Fourier Transform, Transform analysis of LTI systems, Structure for discrete time systems, Digital signal processors, Digitized Image & Its Properties, Data Structure for Image Analysis, Image Processing, Image Transforms, Image Data Compression, 3-D Vision, Geometry and Radiometry.

Sensors and advanced topics: Sensors as system components- Temperature sensors- Force and pressure sensors- Magnetic field sensors - Optical sensors - Microwave sensors - Miscellaneous sensors –MEMS-Fabrication steps.

Reference Books*:*

1. Art of Electronics – Paul Horowitz, Cambridge LPE.
2. Electronics Decives and circuits – An Introduction Allen Mottershed, PHI
3. Digital Principles and applications – A.P. Malvino, Donal Leech. Tata MacGraw Hill fourth Edition.
4. Jan M. Rabaey; Anantha Chandrakasan; Borivoje Nikoli´c, “Digital Integrated Circuits A Design Perspective”, (Second Edition) Prentice-Hall Electronics and VLSI Series. (2003)
5. Behzad Razavi,”Design of Analog CMOS integrated circuits”, McGraw Hill International Edition. 2001.

6. Millman & Halkias: Basic Electronic Principles; TMH.
7. Behzad Razavi,"RF Microelectronics", PHI International Second Edition. 2012.
8. Neil H.E. Weste, Kamran Eshraghian, "Principles of CMOS VLSI Design, Addison-Wesley Publishing Company.
9. Millman & Halkias – Integrated El;ectronics, Tata McG
10. Handbook of Modern Sensors by Fraden
11. D. V.S.Murthy, Transducers in instrumentation, Prentice Hall, 1995.
12. J. P.Bentley, Principles of measurement systems, Wiley,1989
13. J. W.Gardner, Microsensors, principles and applications, Wiley,1996.
14. S.M.Sze, Semiconductor Sensors, Wiley,1994

EE664 Inertial Sensors and Systems (SEM I) 3-0-3

Unit 1: Basic principles of Navigation and Inertial Navigation, Gimbaled platform and Strapdown Navigation systems, Overview of Inertial Sensors.
Sensors as system components- Temperature sensors- Force and pressure sensors- Magnetic field sensors - Optical sensors - Microwave sensors - Miscellaneous sensors –MEMS- Fabrication steps.

Unit 2: Gyroscope working principle. Single degree of freedom rate gyro and rate integrating gyro. Dynamically Tuned Gyroscope: Principle of operation, Design features, Single gimbal and dual gimbal flexures, Rebalance loop configuration, DTG errors and error model. Ring Laser Gyro: Principle of operation and different types, Sagnac Effect, Design features, Lock in and Dither, RLG errors and error model. Fiber Optic Gyro: Principle of operation, Difference with RLG, Design features, open loop and closed loop operation, Error sources in FOG, difference between Fiber optic laser gyro and ring laser gyro. Hemispherical Resonator Gyro: Principle of operation, Design features, HRG errors and error model. Other types of gyros: Nuclear Magnetic Resonance Gyro, Electrostatically Suspended Gyro, Atom Interferometric Gyro etc.

Unit 3: Configuration, working principle and design of pendulous servoaccelerometers. Servoaccelerometer errors and error model. Other types of accelerometers: Vibrating Beam Accelerometer, Fiber optic Accelerometers, Atom Interferometric Accelerometer etc.

Unit 4: MEMS Inertial Sensors: Introduction to MEMS Inertial Sensors, Overview of MEMS Fabrication Techniques. MEMS Accelerometers: Pendulous and non-pendulous accelerometers, Resonant beam accelerometer. MEMS Gyros: Coriolis Vibrating gyro principle, Tuning fork gyro, Comb structure and Ring structure mechanisations.

Unit 5: Inertial Navigation Systems: Gimbaled platform technology and Strapdown system technology, their mechanisation. Redundant Inertial Navigation Systems: Basic concepts of sensor redundancy, redundant sensor configurations, Sensor Failure detection and Isolation. Strapdown INS realization: Basic concepts of system configuration, vibration isolation and temperature control/compensation.

Unit 6: Testing of Inertial Sensors and Systems: Basic concepts and test philosophy. Gyroscope Testing: Multiposition test and Rate test, Frequency response test, Thermal test, Magnetic sensitivity test, Vibration test and Shock test. Accelerometer Testing: Multiposition test, Centrifuge test, Frequency response test, Thermal test, Magnetic sensitivity test, Vibration test and Shock test. Gyro and Accelerometer error modeling and compensation. INS Testing: Rate

test and Multiposition test, Attitude test, Static navigation test, Hardware in Loop tests, Environmental tests like EMI, Thermal, Vibration and Shock.

Reference Books:

1. Strapdown Inertial Navigation Technology: by D.H.Titterton and J.L.Weston.

2. Modern Inertial Sensors and Systems: by Amitava Bose, Somnath Puri and Paritosh Banerjee.

3. Fundamentals of Navigation and Inertial Sensors: by Amitava Bose, K.N.Bhat and Thomas Kurian

4. AGARD-LS-95: Strapdown Inertial Systems.

ME 626 Introduction to Robotics (SEM I) 3-0-3

Robot definition, Robotics and programmable automation Historical background, laws of Robotics. Robotics systems and Robot anatomy, specification of Robots. Robot geometrical configuration. Nano robots.

Performance Definition - Accuracy / Repeatability / Precision with respect to Position & Path, payload, speed, acceleration, cycle time.

Homogeneous coordinate transformations, Mathematical description of objects. Description of a wedge by transformation matrices, Relative transformations in the robot workspace. Description of manipulator joints, Assignment of coordinate systems to robot joint and derivation of transformation matrices.

Classification of end effectors, Types of Grippers Hooks, scoops and other devices, Gripper force analysis and design of Drive system for gripper.

Euler angles for specifying orientation, Euler angles for roll-yaw-roll geometry, Gripper positioning by Euler angles for roll-yaw-roll geometry - Euler angles for roll - pitch - yaw geometry, Cylindrical Robot coordinates polar Robot coordinates, calculation of cylindrical, polar coordinates, Some applications.

Text/References

1. Francis N. Nagy, Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987
2. Richard D. Klafter, Thomas. A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989
3. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995

4. Mikell P. Grooyer, Mitchell weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics, Technology programming and Applications, Mc Graw Hill International Edition, 1986
5. S.R. Deb, Robotics Technology and flexible automation, Tata Mc Graw Hill Publishing company Ltd., 1994
6. Carl D. Crane and Joseph Duffy, Kinematic Analysis of Robot manipulation, Cambridge University press, 1998

ME 627 Mechatronics (SEM I) 3-0-3

Concept of Mechatronics, Concept of Control System, Study of examples of Mechatronic Systems, Key Components of Mechatronic Systems, Mechanical Components, Mechanical assemblies like Rotating Shafts, Linear Slides, Gear Systems, Ball Screws, Cams, ropes, belts & pulleys

Control Components like Actuators, Sensors, Controllers & Drives, Control Circuits like Logic Control circuits, Servo Loops, Hydraulic & Pneumatic circuits, Tooling Components like Grippers, Hands, Process tools, Energy Absorbing Devices, Cable Management Devices, Kinematic Chains, and Failure Modes in Mechatronic systems

References/ Texts:

1. Bolton.W., 'Mechatronics', Addison- Wesley, 2nd edition, 1999
2. Michael.B.B. Histand, 'Introduction to Mechatronics and measurement systems', McGraw-Hill International Edition, 1999
3. Goankar. R.S., 'Microprocessor Architecture Programming and Applications', Wiley Eastern, 1997

AE 619 Robotic Control (SEM II) 3-0-3

Introduction to feedback system, Mathematical modeling: Transfer functions; Block diagrams; Time domain analysis; Frequency Domail Analysis; Stability. Designs of compensators; Introduction to state space methods. State space representation of dynamical systems. Solution of state equation. Controllability and observability. State feedback control, Pole placement techniques, Design of observers.

Robot dynamics, equation of motion, Linearization, Independent Join Control, PID based set point tracking, feedforward control and computed torque method, multivariable control, force control, control of robot based on feedback linearization, Robust control of robots

References and Text

1. K. Ogata, Modern Control Engineering, 5th Edition, Prentice Hall, 2010
2. B. Friedland, Control System Design-An Introduction to State Space Methods, McGraw-Hill, Singapore, 1987
3. J.J.E Slotine and W. Li, Aplied Nonlinear Control, Prentice-Hall, NJ, 1991
4. M. W. Spong and M. Vidyasagar, Robot Dynamics and Control, John Wiley & Sons, NY, USA, 2004

ME 628 Robot Kinematics and Dynamics (SEM II) 3-0-3

Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effectors.

Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates, link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and six axis Articulated Robots.

The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and six axis Articulated robot.

Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, continuous path motion, Interpolated motion, straight line motion.

Introduction, lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot Newton Euler formulation, Lagrange - Euler formulation, problems.

Text/References:

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2000

2. Richard D. Klafter, Thomas. A, Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989
3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995
4. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987
5. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house, 1993
6. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001
7. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999
8. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robtics and Automation Sensor - Based integration, Academic Press, 1999

EE 609 Microcontroller and Embedded Systems (SEM II) 3-0-3

Introduction: Introduction to 8051 Microcontroller programming and applications, Definition and Classification, Overview of Processors and hardware units in an embedded system, Software embedded into the system, Exemplary Embedded Systems, Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits

Devices and buses for devices network
I/O Devices, Device I/O Types and Examples, Synchronous, I/o synchronous and Asynchronous Communications from Serial Devices, Examples of Internal Serial-Communication Devices, UART, Parallel Port Devices, Sophisticated interfacing features in 143
Devices/Ports, Timer and Counting Devices, '12 C', 'USB', 'CAN' and advanced I/O Serial high speed buses, ISA, PCI, PCI-X and advanced buses

Embedded computing Embedded processors, ARM processor, Architecture, Instruction sets and programming. Case Studies

Advanced embedded computing Programmable System on Chip, Cypress PSoC Technology. Advance DSP Processors. FPGA Technology towards Embedded system aspects- Pico blaze and micro blaze processors- Embedded RAM- Embedded multiplier FPGA coding using VHDL/Verilog Associated Labs: Assignements using Microcontroller kits, FPGA kits.

Texts:
1. ARM System-on-Chip Architecture (2nd Edition) Steve Furber
2. Real-time digital signal processing: Based on the TMS320C6000, Nasser Kehtarnavaz
3. Advanced FPGA Design: Architecture, Implementation, and Optimization, Steve Kilts, IEEE press Wiley 2007

References:

1. http://www.xilinx.com/publications/xcellonline : Xcell Journal
2. DSP Architecture, Programming and Application- B Venkataramani, M Bhaskar
3. Wayne Wolf, Computers as Components; Principles of Embedded Computing System Design – Harcourt India, Morgan Kaufman Publishers, First Indian Reprint 2001

ME 638 Field and service Robots (Sem II) 3-0-3

1. Introduction to Field and service robots:

History of service robotics – Present status and future trends – Need for service robots – applications examples and Specifications of service and field Robots. Non conventional Industrial robots. Classification, applications, sensing and perception, social and ethical implications of robotics.

2. Autonomous Mobile robots:

Kinematics, locomotion, perception, motion planning and control, localization and mapping. Road map path planning, Intelligent unmanned vehicles. Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Models of emotion and motivation. Performance, Interaction, Safety and robustness,

3. Field Robots

Collision avoidance-Robots for agriculture, mining, exploration, underwater, civilian and military applications, nuclear applications, Space applications. Industrial applications like cleaning robots, wall painting robots, wall plastering robots, vehicle equipment and building robots etc Load carrying robots. IDE detection and diffusion robots

4. Underwater robots:

Kinematics and dynamics, modeling and simulation, navigation, guidance and control. Marine data collection (Temperature, other environment parameters)

5. Aerial robots:

Basics of aerial robots, sensors and actuators, modelling and control of small Unmanned Aerial vehicles, guidance and navigation of small range aerial robots, Autonomous indoor flight control Air defence robots

References:

Text Books:

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, „Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA, 2004
2. Riadh Siaer, „The future of Humanoid Robots- Research and applications", Intech Publications, 2012.

Reference books:

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
2. Kelly, Alonzo; Iagnemma, Karl; Howard, Andrew, "Field and Service Robotics ", Springer, 2011

ELECTIVES

AE 612 Nonlinear and Robust Control (SEM II) 3-0-3

Introduction to Nonlinear Systems, Stability analysis, Feedback linearization, Input-State and Input-Output Linearization, Robust Feedback Linearization. Sliding Mode Control and Sliding Mode Observers. Uncertainties, variation and unmodelled lags. Robust control based on Uncertainty and Disturbance Estimation. Time Delay Control, Inertial Delay Control. Disturbance Observer. State and Disturbance Observers. Applications in missile and aircraft autopilot design.

Texts/ References:

1. J.J.E. Slotine and W. Li, Applied Nonlinear Control, Prentice-Hall, NJ, 1991.
2. P. Garnell: Guided Weapon Control Systems, Pergamon Press, London, 1980.
3. A. Sabanovic, L. Fridman, and S. Spurgeon, Variable Structure Systems: From Principles to Implementation, IEE Control Series No. 66, 2004.

AE 617 Introduction to UAVs 3-0-3

Definition of UAVs. Basic Elements of UAVs. History of UAVs, Military and other applications of UAVs, Classification of UAVs, Comparison of manned aircrafts, missiles and UAVs, Comparison of design complexities of aircrafts, missiles and UAVs, UAV Concepts. Fixed wing, rotary wing and blended wing UAVs, Flight Instrumentation and Data Acquisition Systems, Actuators and Sensors of UAVs, UAVs currently in operation. Armed-Killer UAVs. Countering UAVs

Text/References:

1. Unmanned Aircraft Systems: A Global View By J. Jayaraman. DRDO, 2014.
2. Missile Design and System Engineering By Eugene L. Fleeman. AIAA Foundation Series, 2014.
3. Performance, Stability, Dynamics, and Control of Airplanes. By Bandu N. Pamadi. AIAA Education Series, 1998.
4. Missile Configuration Design. By S.S.Chin. McGraw Hill Book Company, Inc., 1961.

AM 625 Digital Image Processing 3-0-3

Digital image fundamentals: Simple image model, Sampling, Quantization, Introduction to colour images.

Image enhancement in spatial domain: Basic gray level transformations, Histogram processing, Spatial filters.

Image enhancement in frequency domain: Frequency domain filters, Ideal, Butterworth and Gaussian filters.

Image restoration: Noise models, Noise reduction using spatial filters, Noise reduction using frequency domain filters.

Morphological image processing: Dilation, Erosion, Opening, Closing, Applications to; Boundary extraction, Region filling, Extraction of connected components.

Image segmentation: Discontinuity detection, Edge linking and boundary detection, Thresholding, Region based segmentation, Segmentation by morphological watershed.

Object recognition: Decision-theoretic methods.

Image Compression.

Text/References

1. Digital Image Processing, 3rd Ed., 2007, R. C. Gonzalez, Richard E. Woods, Prentice Hall.
2. Digital Image Processing Using MATLAB, 2nd Ed., 2009, R. C. Gonzalez, Richard E. Woods, Steven L. Eddins, Gatesmark Publishing.
3. Digital Picture Processing, 2nd Ed., 1982, A. Rosenfeld, A. C. Kak, Academic Press.
4. Fundamentals of Digital Image Processing, 1st Ed., 1989, A.K. Jain, Prentice Hall of India.
5. Pattern Classification and Scene Analysis, 1973, R. O. Duda, P. E. Hart, John Wiley.
6. Pattern Recognition, Applications to Large Data-Set Problems, 1984, Sing-Tze Bow, Marcel Dekker.

CE 691 Secure Wireless Sensor Network 3-0-3

Background: Wireless Sensor networks (WSN) is an emerging technology and have great potential to be employed in critical situations like battlefields and commercial applications such as building, traffic surveillance, habitat monitoring and smart homes and many more scenarios. One of the major challenges wireless sensor networks face today is security. While the deployment of sensor nodes in an unattended environment makes the networks vulnerable to a variety of potential attacks, the inherent power and memory limitations of sensor nodes makes conventional security solutions unfeasible. The sensing technology combined with processing power and wireless communication makes it profitable for being exploited in great quantity in future. The wireless communication technology also acquires various types of security threats.

Objective: To meet End-User, Network-Administrator and Network-Designer perspectives

Subject Contents:

Introduction, WSN Resources & constraints, Relevance to Cyber-Physical Systems, Relevance to Network Centric Operations, Relevance to Data Stream Management Systems, Relevance to the increasing demand of high performance computations, SCADA, battle sensor

WSN Network Architecture, MAC Layer protocols, Naming and Addressing, Synchronization, Location & positioning, Topology control, Connected Dominating Sets, Routing Protocols, Data-Centric & Content-based networking, Data-Centric querying

Vulnerabilities, threats, attacks & safeguards in WSN, key distribution methods & protocols, multi-party computations inclusion, RF-Id communications, open source hardware concept, Security goals for WSNs, Attacks on WSNs: Passive & Active Attacks, Security Mechanisms, Security Models for WSNs, Challenges in WSNs: with respect to wireless medium, resource scarcity, ad-hoc deployments, hostile environments, immense scale, etc. Application oriented: Secure Wireless Networks.

Research Paper References:

1. Ian F. Akykildiz, Weilian Su, Yogesh Sankarasubramaniam, and Erdal Cayirci, "A Survey on Sensor Networks", IEEE Communication Magazine, year 2002
2. Culler, D. E and Hong, W., "Wireless Sensor Networks", Communication of the ACM, Vol. 47, No. 6, June 2004, pp. 30-33.
3. Adrian Perrig, John Stankovic, David Wagner, "Security in Wireless Sensor Networks" Communications of the ACM, Page53-57, 2004

4. Chris Karlof, David Wagner, “Secure Routing in Wireless Sensor Networks: Attacks and Countermeasures”, AdHoc Networks (elsevier), Page: 299-302, year 2003
5. Al-Sakib Khan Pathan, Hyung-Woo Lee, Choong Seon Hong, “Security in Wireless Sensor Networks: Issues and Challenges”, International conference on Advanced Computing Technologies, Page1043-1045, year 2006
6. John Paul Walters, Zhengqiang Liang, Weisong Shi, Vipin Chaudhary, “Wireless Sensor Network Security: A Survey”, Security in Distributed, Grid and Pervasive Computing Yang Xiao (Eds), Page3-5, 10-15, year 2006
7. Pathan, A.S.K.; Hyung-Woo Lee; Choong Seon Hong, “Security in wireless sensor networks: issues and challenges” Advanced Communication Technology (ICACT), Page(s):6, year 2006
8. Tahir Naeem, Kok-Keong Loo, Common Security Issues and Challenges in Wireless Sensor Networks and IEEE 802.11 Wireless Mesh Networks, International Journal of Digital Content Technology and its Applications, Page 89-90 Volume 3, Number 1, year 2009
9. Undercoffer, J., Avancha, S., Joshi, A. and Pinkston, J. “Security for sensor networks”. In Proceedings of the CADIP Research Symposium, University of Maryland, Baltimore County, USA, year 2002 http://www.cs.sfu.ca/~angiez/personal/paper/sensor-ids.pdf
10. Zia, T.; Zomaya, A., “Security Issues in Wireless Sensor Networks”, Systems and Networks Communications (ICSNC) Page(s):40 – 40, year 2006
11. Xiangqian Chen, Kia Makki, Kang Yen, and Niki Pissinou, Sensor Network Security: A Survey, IEEE Communications Surveys & Tutorials, vol. 11, no. 2,page(s): 52-62, year 2009
12. D. Djenouri, L. Khelladi, and N. Badache, “A Survey of Security Issues in Mobile ad hoc and Sensor Networks,” IEEE Commun. Surveys Tutorials, vol. 7, pp. 2–28, year 2005.
13. S. Schmidt, H. Krahn, S. Fischer, and D. Watjen, “A Security Architecture for Mobile Wireless Sensor Networks,” in Proc. 1st European Workshop Security Ad-Hoc Sensor Networks (ESAS), 2004.
14. Y. Wang, G. Attebury, and B. Ramamurthy, “A Survey of Security Issues in Wireless Sensor Networks,” IEEE Commun. Surveys Tutorials, vol. 8, pp. 2–23, year 2006.
15. Yun Zhou, Yuguang Fang, Yanchao Zhang, Securing Wireless Sensor Networks: A Survey, IEEE Communications Surveys & Tutorials, year 2008
16. Xiuli Ren, Security Methods for Wireless Sensor Networks, Proceedings of the 2006 IEEE International Conference on Mechatronics and Automation , Page: 1925 ,year 2006
17. R.Roman, J. Zhou, and J. Lopez, “On the security of wireless sensor networks,” in International Conference on Computational Science and Its Applications – ICCSA 2005, May 9-12 2005, vol. 3482 of Lecture Notes in Computer Science, (Singapore), pp. 681–690, Springer Verlag, Heidelberg, D-69121, Germany, 2005.
18. N. Sastry and D. Wagner, “Security considerations for ieee 802.15.4 networks,” in Proceedings of the 2004 ACM workshop on Wireless security, pp. 32–42, Philadelphia, PA, USA: ACM Press, 2004.

19. WSN Security Models: Refer 4 papers: **Paper 1:** Wireless sensor network security model using zero knowledge protocol, ICC 2011; **Paper 2.** An energy efficient link-layer security protocol for wireless sensor networks, EIT 2007; **Paper 3.** Toward resilient security in wireless sensor networks, MobiHoc 2005; **Paper 4.** TinySec: a link layer security architecture for wireless sensor networks, SenSys 2004

CE 697 Robot Programming 3-0-3

Robot software functions - coordinate systems, position control, other control functions, subroutines, Program planning for Robot flow charting for robot programs with few examples.

Online programming, off-line programming, advantages of off-line programming, lead through methods - powered lead through, manual lead through, Teach pendant, Robot program as a path in space, defining position in space, motion interpolation, WAIT, SIGNAL and DELAY commands, Branching capabilities and Limitations of head through methods.

Textual ROBOT Languages, first generation and second generation languages, structure of a robot language - operating systems, Elements and Functions, constants, variables and other data objects, Motion commands, points in workspace, End effector and sensor commands, computations and operations, program control and subroutines, communications and Data processing.

General description, Monitor commands, motion command, Hand Control, Configuration control, interlock commands, INPUT/OUTPUT Controls, Program Control, examples.

General description, AML statements, Constant and variables, program control statements, motion commands, Sensor commands, Grip sensing capabilities, Data processing, examples.

Texts:

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, 'Industrial Robotics Technology, Programming and Applications', Mc Graw Hill Book company, 1986
2. Bernard Hodges, 'Industrial Robotics', Second Edition, Jaico Publishing House, 1993

CE 698 Computer Graphics 3-0-3

Intoduction, OpenGL®, Geometry

Math for Computer Graphics,Transformations,More Transformations,Viewing and Cameras,Curves and Splines,Meshes and Surfaces.

Shading and Light,Shading and Textures,Color / Light, Ray Tracing, Spatial Data Structures,More Ray Tracing.

Radiosity, Photon Mapping, Differential Equations and Particle Systems, Cloth and Fluids Character Animation.

Direct / Indirect Separation, NPR, Illusions, Image Processing- an introduction, Cameras and Displays

Texts/References

1. Computer Graphics by Bhatia, I. K. International Pvt Ltd, 01-Jan-2008
2. Computer Graphics**:** Principles and Practice by J D Foley, 1996

EE604 Digital Communication 3-0-3

Unit I: Elements of Digital Communication Systems: Model of Digital Communication Systems, Digital Representation of Analog Signal, Bandwidth-S/N tradeoff, Hartley Shannon Law, Sampling Theorem, Pulse Code Modulation, PCM Generation and Reconstruction, Quantization noise, Non uniform Quantization and Companding, DPCM, Adaptive DPCM, DM and Adaptive DM. Noise in PCM and DM, , Information Capacity, Bits, Bit Rate, Baud rate & M-ary Encoding

Unit II: Digital Modulation Techniques: Introduction, Pulse amplitude modulation (binary and M-ary, QAM), Pulse position modulation (binary and M-ary), Carrier modulation (M-ary ASK, PSK, FSK, DPSK), Continuous phase modulation (QPSK and variants, MSK, GMSK), Trellis Code Modulation, Probability of Error & Bit Error Rate, Error Performance.

Unit III: Information Theory: Information and entropy, conditional entropy and redundancy, Shannon Fano coding, Mutual Information, Information loss due to noise, source codings - Huffman Code, variable length coding, Source coding to Increase average Information per bit. Lossy source coding, Baseband transmission and Optimal Reception of Digital Signal: Pulse shaping for optimum transmissions. A Baseband Signal Receiver, Probability of Error. Optimum Receiver, optima of Coherent Reception. Signal Space Representation and Probability of Error, eye diagrams, Cross talk.

Unit IV: Coding Techniques: Matrix description of Linear Block Codes, Error detection and error Correction capabilities of linear block codes, Cyclic Codes: Algebraic structure, encoding, syndrome calculation, Decoding Convolution Codes: Convolution Codes: Encoding. Decoding using State, tree and trellis diagrams. Decoding using Viterbi algorithm. Comparison of Error Rates in Coded and Uncoded Transmission.

Unit-V: Spread Spectrum & Multi User Communication:
Model of a Spread Spectrum Communications System, Direct Sequence Spread spectrum Signals, Frequency Hopped Spread Spectrum Signals, Other types of Spread Spectrum Signals, Spread Spectrum in multipath channels, Multiple Access Techniques (CDMA,

TDMA, FDMA, SDMA, PDMA), Capacity of Multiple Access Systems, Multichannel and Multicarrier System, Multichannel Digital Communications in AWGN Multicarrier Communications

Text books:

1. Principles of communication systems - Herbert Taub. Donald L Schiling, Goutam Sana, 3rd Edition,McGraw-Hill, 2008.
2. Digital and Analog Communicator Systems - Sam Shanmugam, John Wiley, 2005.
3. Advanced Electronic Communications Systems, by Wayne Tomasi, 6 Edition Pearson Education.

Reference books:

1. Digital Communications - John G. Proakis . Masoud salehi – 5th Edition, McGraw-Hill, 2008.
2. Digital Communication - Simon Haykin, Jon Wiley, 2005.
3. Digital Communications - Ian A. Glover, Peter M. Grant, Edition, Pearson Edu., 2008.
4. Communication Systems-B.P. Lathi, BS Publication, 2006.

EE613 Electronic Warfare 3-0-3

Unit-1: Introduction to Electronic Warfare:
Electronic Defence, Electronic Combat (ESM-ECM-ECCM), Radar Basics (Radar Technology Evolution, Radar Range Equation, RCS Reduction, Counter-Low Observable), SIGNIT, Intercept System Characteristics and Functions, Frequency Coverage, Analysis Bandwidth, Wideband Radar Signal Trends, Dynamic Range, Dynamic Range Requirements, Sensitivity, Noise Figure Measurement, Y-Factor Measurement, Some Sensitivity Measures, Output SNR and Receiver Applications, Threshold Detection, Sensitivity and the Received Pulse Density, The Ultimate Limits to ELINT Parameter Measurements, Probability of Intercept.

UNIT-2: Electronic Support Measures:
Typical ESM Systems, ESM Sensitivity, ESM Receivers - Crystal Video Receiver, IFM Receiver, Superheterodyne Receiver, Channelized Receiver, Bragg Cell Receiver, Compressive Receiver, Digital Receivers. DOA/AOA Measurement Emitter Location - The Role of Emitter Location ,Emitter Location Geometry ,Emitter Location Accuracy, Amplitude-Based Emitter Location, Interferometer Direction Finding, Interferometric DF Implementation, Direction Finding Using the Doppler Principle, Time of Arrival Emitter Location.

UNIT-3: Electronic Counter Measures:
Principals of Electronic Attack (EA), Jamming-to-Signal Ratio , Jamming Types(Burn-Through, Cover Jamming ,Range Deceptive Jamming, Inverse Gain Jamming, Repeater Jamming Equations, Noise Jamming vs. Deception, Repeater vs. Transponder, Sidelobe Jamming vs. Mainlobe Jamming, Stand-Off Jamming, Escort Jamming, Self Protection Jamming, ECM techniques, On-Board ECM Systems, Off-Board ECM Systems, Infrared Countermeasures (IRCM), Off-Board ECM Systems, Communications Countermeasures

(COM-ECM), Electro-Optic Counter Measure (Eocm) Systems, Airborne Tactical Jamming System, Shipboard Self-Defense System, EA/Susceptibility against Weapon Systems.

Unit-4: Electronic Counter-Countermeasures
Search Radar Counter-Countermeasures, Tracking Radar Counter-Countermeasures, Infrared Counter-Countermeasures, Communications Counter-Countermeasures.

Unit-5: New Electronic Defense Techniques
New Electronic Defense Techniques and Technologies trend, Shared Apertures/MRFS, Anti Anti-Radiation Missile Techniques, Anti-Stealth Techniques, RF Direct Energy Weapons, Design and Evaluation Criteria: Design Criteria, Evaluation Criteria for the Choice of a System, Operational Effectiveness, Electronic Defense and Conventional Defense, Electronic Warfare Digitization.

Text Books:

1. EW101: A First Course in Electronic Warfare, David Adamy, Artech House
2. EW102: A Second Course in Electronic Warfare, David Adamy, Artech House
3. Introduction to Electronic Defense Systems, Second Edition, Artech House by Filippo Neri
4. Introduction to Electronic Warfare 1984, Schleher Dc, Artech House
5. Microwave Receiver with EW applications, 1986, James Bao & Yen Tsui, Wiley and Sons.

Reference Books:

6. Electronic Warfare in the Information Age, 1999,D. Curtis Schleher, Artech House, Boston, London
7. Radar hand book, 1972/1990, Skolnik MI, Mc Graw Hill.
8. Fundamentals of Electronic Warfare, Artech House by Sergei A. Vakin

EE 618 DSP System Design 3-0-3

Unit I Introduction:

Digital Signal processing and DSP systems, Comparison between general purpose and DSP processors. Examples of digital signal processors, Motivation of the specialized processors. Fixed point vs Floating point, native data word width. Importance of the course, why FPGAs lend to high-performance DSP design

Unit II VHDL Simulation and Synthesis:

VHDL Code Structure, Data types, Operators, Concurrent & Sequential code, Library Packages, Functions Procedures, Test bench. Combinational circuits, Binary Adders, Binary Multipliers, Multiply Accumulator (MAC).CORDIC Algorithm. Sequential circuits, Mealy and Moore machine, Frequency synthesizer, PLL, DDS (Direct digital Synthesizer).

Unit III Implementation of Digital Filter.

Digital filters: Review of FIR and IIR filters, Optimal FIR filters ,Spectral or frequency transformation of IIR filters, cascaded and lattice structures of FIR and IIR filters, Comparison of FIR and IIR filters.

Unit IV Multi Rate Filters

Multirate signal processing – Decimation by a integer factor , Interpolation by a integer factor , Sampling rate conversion by a rational factor , Design of practical sampling rate converters, Software implementation of sampling rate converters, Applications of Multirate signal processing.

Unit V Case Studies

VHDL Design with Basic displays, **CIC Filter Implementation, Designing a MAC FIR** - Serial Communication circuits, Digital Correlation by FFT. QPSK Transmitter Model, Receiver Model

Text Books:

1. Digital Signal Processing with Field Programmable Gate Arrays (Signals and Communication Technology). Uwe Meyer-Baese Second Edition Springer Publication 2007
2. Advanced FPGA Design: Architecture, Implementation, and Optimization, Steve Kilts, IEEE press Wiley 2007
3. http://www.xilinx.com/publications/xcellonline/ - Xcell Journal

EE 621 Digital Interface Design 3-0-3

Introduction:

Definition and Classification, Overview of Robots and hardware units in Robotics, Introduction to Zed Board Embedded Systems on a Chip (SoC) and the use of FPGA in Robotics Application. State Machines and applications.

Sensor and actuator interfacing:

Sophisticated interfacing features in Devices/Ports, Timer and Counting Devices, 'I2C', 'USB', 'CAN'.PWM in HW for robot control.LCD interfacing with FPGA.

Data convetors interfacing:

Introduction to ADC and DAC .Various Types and specification. SPI interfacing in FPGA.

Wireless and gps interfacing

Introduction to Bluetooth- Zig Bee Interface . Introduction to Gyro and accelerometer – Gyro accelerometer interface using Complementary Filter.

Case study:

Underwater Glider motion controller. NI CompactRIO embedded control hardware for rapid prototyping.

Text Books:

1. Advanced FPGA Design: Architecture, Implementation, and Optimization, Steve Kilts, IEEE press Wiley 2007

2. Yale Patt and Sanjay Patel,Introduction to Computing Systems: From Bits and Gates to C and Beyond, 2nd edition, Publication Date: August 5, 2003 | ISBN-10: 0072467509 | ISBN-13: 978-0072467505.
3. Rapid Prototyping of Digital Systems: **Hamblen**, James O., **Hall**, Tyson S., **Furman**, Michael D. Springer 2008
4. The Zynq Book Tutorials: Louise H. Crockett Ross A. Elliot Martin A. Enderwitz Robert W. Stewart

ME 609 Mechanical Vibrations 3-0-3

Single Degree of Freedom Systems: Free and forced vibrations of damped and undamped systems; Simple harmonic excitation; steady state response; torsional vibrations.

Vibration of Systems with Two Degrees of Freedom: Free and forced vibration of spring-mass-damper systems; torsional vibrations; modal analysis of undamped and damped systems; numerical methods: Matrix iteration, Holzer's method, Dunkerley's lower and Rayleigh's upper bound approximations; Dynamic vibration absorbers

Vibration of Multi-degree of Freedom and Continuous Systems: Vibrating string; Longitudinal and torsional vibration of rods; Free and forced vibration of beams; Properties of vibrating systems: Flexibility and stiffness influence coefficients; Reciprocity theorem; Eigenvalue analysis; Orthogonality of eigenvectors; Modal matrix

Experimental methods in vibration analysis: Vibration instruments: exciters, transducers, analysers, measurement devices: vibrometers, velocity meters and accelerometers; Signal analysis techniques: time domain analysis, frequency domain analysis, amplitude and power spectra, coherence, auto and cross correlations, amplitude and frequency modulations; Tests for free and forced vibrations

Case studies: Vehicle dynamics: introduction to nonlinear and random vibrations, vehicle subjected to random vibrations (for example an uneven road); Fluid-structure interaction problems: vibration of suspension bridges

Text Books*:*

1. "Introductory Course on Theory and Practice of Mechanical Vibrations", J.S.Rao, K.Gupta, Revised second edition, New Age International Publishers

2. "Theory of Vibration with Applications", William T. Thomson, Marie Dillon Dahleh, Pearson Low Price Edition.
3. Mechanical Vibrations, J.B.K. Das & P.L.S.Murthy, Sapna book house.

Reference Books*:*

1. Principles and Techniques of Vibrations, Leonard Meirovich, Prentice Hall Inc.
2. Engineering Vibration, DJ Inman, Prentice Hall International Inc.
3. "Mechanical Vibration and Shock Measurements", J.T.Broch, Bruel and Kjae Publication.
4. "Applications of Random Vibrations", N. C. Nigam, S. Narayanan, Narosa Publishers.

ME 629 Industrial Automation 3-0-3

Production operations and Automation strategies - Types of production, Functions in manufacturing, Plant Layout, Production concepts and Mathematical models, Automation strategies. Production Economics - Cost in manufacturing, Break even analysis, Unit cost of production, Cost of manufacturing lead time and work-in-progress.

Detroit - Type automation - Automated flow line, workpart transport, Transfer mechanism, Buffer storage, Control functions, Automation for machining operations, Design and fabrication consideration. Analysis of Automated Flow lines. General terminology and analysis, Analysis of transfer lines without storage, partial automation, Automated flow lines, with storage buffer, simulation of automation flow lines.

Numerical Control, Types of NC Systems, Machine tool applications, other applications of NC Systems, Components of NC System, Introduction to NC part programming, Types of part programming, Direct Numerical Control, Computer Numerical Control, Adaptive Control Machining.

The assembly process, assembly systems, manual assembly lines, The line balancing problem, Methods of line balancing, Computerised line balancing method, flexible manual assembly lines.
Design for automated assembly, types of automated assembly system, parts feeding devices, Analysis of single station and multistation assembly machine.

Automated materials handling : Types of material handling equipment, analysis for material handling systems, design of the system, conveyor system, automated guided vehicle systems. Automated storage systems : Automated storage / Retrieval systems, Carousel storage systems, work-in-process storage, interfacing handling and storage with manufacturing.

References/Texts

1. Mikell.P.Groover, Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India Pvt. Ltd., Thirteenth Indian Reprint, 2001
2. P.N.Rao, 'CAD/CAM Principles and Applications' Tata McGraw Hill Publishing Company Ltd., 2002

ME 635 CAD/CAM 3-0-3

Criteria for selection of CAD workstations, Shigle Design Process, Design criteria, Geometric modeling, entities, 2D & 3D Primitives. 2D & 3D Geometric Transformations: Translation, Scaling, Rotation, Reflection and Shearing, concatenation. Graphics standards: GKS IGES, PDES. Wire frame modeling: Curves: Curve representation. Analytic curves – lines, Circles, Ellipse, Conis. Synthetic curves – Cubic, Bezier, B-Spline, NURBS.
Surface entities, Surface Representation. Analytic Surface – Plane Surface, Ruled Surface, Surface of Revolution, Tabulated Cyliner. Synthetic Surface-Cubic, Bezier, Bspline, Coons.

Graph Based Model, Boolean Models, Instances, Cell Decomposition & Spatial – Occupancy Enumeration, Boundary Representation (B-rep) & Constructive Solid Geometry (CSG).

Feature Based Modeling, Assembling Modeling, Behavioural Modeling, Conceptual Design & Top Down Design. Capabilities of Modeling & Analysis Packages such as solid works, Unigraphics, Ansys, Hypermesh. Computer Aided Design of mechanical parts and Interference Detection by Motion analysis.

Text/Reference

1. CAD/CAM: Computer-Aided Design and Manufacturing by M Groover and E. Zimmers, Pearson Education, 1983.
2. CAD/CAM in Practice by A J Medland, Springer science and media, 2012

ME634 Flexible Manufacturing Systems 3-0-3

Definition of an FMS-need for FMS, types and configuration, types of flexibilities and performance measures. Economic justification of FMS. Development and implementation of FMS- planning phases, integration, system configuration, FMS layouts, simulation

Functions - types - analysis of material handling systems, primary and secondary material handling systems-conveyors, Automated Guided Vehicles-working principle, types, traffic control of AGVs. Role of robots in material handling.

Automated storage systems- storage system performance - AS/RS-carousel storage system, WIP storage systems, interfacing handling and storage with manufacturing.

Planning, scheduling and computer control of FMS, Hierarchy of computer control, supervisory computer. DNC system- communication between DNC computer and machine control unit, features of DNC systems.

System issues, types of software - specification and selection- trends-application of simulation and its software, Manufacturing Data systems- planning FMS data base. Modelling of FMS- analytical, heuristics, queuing, simulation and petrinets modeling techniques.

Scheduling of operations on a single machine- two machine flow shop scheduling, two machine job shop scheduling, - three machine flow shop scheduling- scheduling 'n' operations on 'n' machines, knowledge based scheduling, scheduling rules, tool management of FMS, material handling system schedule.

References/ Texts:

1. Handbook of Flexible Manufacturing Systems by N K Jha, Academic Press, 02-Dec-2012
2. Flexible Manufacturing Systems: Recent Developments, A. Raouf, M. Ben-Daya Elsevier, 09-Feb-1995

TM 609 System Engineering 3-0-3

Large scale systems, Generic systems, System Engineering(SE) frame work, SE dimentions, SE Matrix, tools of SE- Words, graph, mathematics, Structural Modelling, Flexible imperative structure modelling, Algorithms of FISM, Cross impact models, Deterministic models- Kane simulations and weighted graph models, Monte Carlo models

References:

1. George, A Hazelrigg, System Engineering: An Approach to Information based Design, Prentice Hall NJ, 1996.
2. Benjamin, A. Balachard and Walter, J Fabrycky, System Engineering and Analysis, 3rd ED., Prentice Hall International Series, Industrial & System Engineering

AP 610 Nanotechnologies 3-0-3

1. Implications of nano size on physical and chemical properties: Density of States, 2D, 1D, 0D, Quantum size effect, large surface to volume ratio, surface functionalization, tenability of properties, **:** Physical Chemistry of solid surfaces**,** crystal structures, surface energy, chemical potential, Fundamentals of nucleation and growth, Electrostatic Stabilization Surface charge 86 density, Electric potential at the proximity of solid surface, Van der Waals attraction potential, Interactions between two particles: DLVO theory, Solvent and polymer, Interactions between polymer layers, Mixed steric and electric interactions

2. Nanoscale Phenomenon: Nanoparticles, nano-clusters, nanotubes, nanowires and nanodots. Electronic structure: quantum dots, quantum wires and quantum wells, confinement of electrons energy quantization semiconductor nanocrystals, carbon nanotubes, quantum wells.

3. Characterization and properties of nanomaterials: Structural Characterization, X-ray diffraction (XRD), Small angle X-ray scattering **(SAXS)**, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning probe microscopy (SPM), Surface plasmon resonance, Quantum size effects, Surface scattering, Change of electronic structure, Quantum transport, Effect of microstructure, Ferroelectrics and dielectrics, Superparamagnetism.

4. Nano Sensors: Metal nanoparticle-based Sensors, Quantum Dot, Nanowire-based Sensors, Carbon Nanotubes-based Sensors, Sensors Based on Nanostructures of Metal Oxide, Mass-Sensitive Nanosensors, Arrays of Nanomaterial-based Sensors: A representative example for the imitation of human senses by means of nanotechnology and nanosensors: electronic skin based on nanotechnology.

Text/References

1. Nanostructures & nanomaterials Synthesis, Properties & Applications, Guozhong Cao, Imperial College Press (2004).
2. Introduction to Nanotechnology, Charles Poole Jr and Frank J Owens, Wiley India, New Delhi (2006)
3. Nanophysics and Nanotechnology, Edward L Wolf, Wiley-VCH, Verlag (2006)
4. Ramsden Jeremy, Nanotechnology, an Introduction. Elsevier (2011).
5. Florinel-Gabriel Banica, Chemical Sensors and Biosensors: Fundamentals and Applications, John Wiley and Sons (2012)

EE662 Inertial Navigation Systems 3-0-3

Frames of references and inertial navigation fundamentals

Concept of frames of references: inertial frames, non-inertial frames, geographic frame, geocentric frame, body frame; **Principles of inertial navigation**: types of inertial navigation, stabilized platform and strapdown systems, comparison; **Earth models:** ellipsoid geometry, ellipsoid gravity, earth gravity field, gravitational potential, gravity and gravitation, plum-bob gravity; **Concepts of coordinate transformations:** direction cosine matrix(DCM), Euler angles, quaternion; relation between DCM, Euler angles & quaternion

Concepts of strapdown inertial navigation

Inertial measurements: concept of specific force, basic principles of accelerometer: pendulous and vibrating beam, basic principle of gyroscope: mechanical and optical; **Navigation equations**

formulation: forces in inertial & non-inertial frames, navigation equations in inertial & non-inertial frames, choice of reference frame, strapdown system mechanization for different frames: inertial frames, earth fixed frames, geographic frames

Strapdown inertial navigation computations
Sensor geometry: measurement model, concepts of DOP, failure detectability, optimal sensor geometry for different number of sensors; sensor modeling & compensation algorithms (scale factor, bias, misalignment etc.), practical constraints; **Failure detection and isolation**: concepts of parity vectors, generalized likelihood test; **Attitude propagation algorithm:** using Euler angle, DCM and quaternion; quaternion in terms of rotation vector, first and second order orientation vector algorithms for quaternion propagation, acceleration transformations, velocity & position update algorithms, numerical integration methods, comparison

Inertial navigation system alignment
Initialization of inertial navigation system; **Principle of alignment**: alignment on a fixed platform: azimuth and level alignment, alignment on a moving platform: in-flight alignment and shipboard alignment: one shot transfer alignment, measurement matching, methods of measurement matching; gyro-compassing; self corrective alignment scheme

Navigation System Simulation and Error Analysis
Error Analysis: development of perturbation models, attitude response under angular vibration, velocity response under combined angular and linear vibration, size effect errors, modeling of sensor assembly response to system level vibration; specialized error analysis for strapdown mechanization, **INS Simulation:** simulation of sensors, measurement electronics and navigation algorithm; **Navigation algorithm validation**: comparison testing, closed loop simulations using NGC software together, hardware in-loop simulations; static navigation test, Monte Carlo & covariance analysis; **General strapdown algorithm validation:** spin-cone, spin-accel, spin-rock-size, gen-nav

Advanced navigation concepts
Fundamentals of screw theory; fundamentals of Clifford algebra; dual quaternion and its applications in navigation

References:

1. David A Vallado; Fundamentals of astrodynamics and applications,
2. Kenneth R Britting; Inertial navigation system analysis
3. David H Titterton & John L Weston; Strapdown inertial navigation technology
4. Robert M Rogers; Applied mathematics in integrated navigation systems
5. Paul G Savage; Strapdown analytics
6. Mark A Sturza; Navigation System integrity monitoring using redundant measurements, Navigation: journal of institute of navigation, vol35, No.4, winter1988-89,
7. Oleg Salychev; Applied Inertial Navigation: Problems & Solutions

EE 607 Advanced Wireless Communication

Introduction

Wireless Communication Overview, Wireless Spectrum, Wireless Transmission, TDM, FDM, CDM, Medium Access Control, Capacity of Wireless Channels, Digital Modulation and its performance, Mobility Management - Handoff and Roaming

Cellular networks: Cellular Communications, Principles of Cellular Networks,1G Wireless – AMPS, 2G Wireless - GSM, CDMA, CDPD,2.5 Wireless - Why, what, whodunit? , HSCSD, GPRS, EDGE, 3 G Wireless -WCDMA, CDMA2000, WiMAX, HSPA, HSDPA, 4G, LTE, 5G 802: Overview & Architecture, 802.1: Bridging & Management, 802.2: Logical Link Control, 802.3: Ethernet, 802.11: Wireless LANs, 802.15: Wireless PANs, 802.16: Broadband Wireless MANs, 802.17: Resilient Packet Rings, 802.19: TV White Space Coexistence Methods, 802.20: Mobile Broadband Wireless Access, 802.21: Media Independent Handover Services, 802.22: Wireless Regional Area Networks, Zigbee 142

Wireless network security Overview of wireless technology: threats, vulnerabilities and safeguards, Cellular and PCS network security**,** secure wireless encrypted e-mail solution**,** Wireless handheld device security**,** Personal Area Networks security (e.g. Bluetooth)**,** Wireless LAN security (IEEE 802.11)

Spread spectrum Multicarrier Modulation, Spread Spectrum, DSSS, FHSS, CDMA, Block diagram, Multiuser Communications & Wireless Networks, MIMO Systems **Sensor networks** Sensor Networks, Ad-hoc Networks, Sensor nodes (Motes), architecture, Applications of Sensor Networks, Routing protocols, Localization OS for sensor networks: Tiny OS **Mobile devices** PDAs, Cellphones, Smart Phones, OS for Mobile Devices: Symbian, iOS, Embedded Linux Platforms: Android platform, Virtual Machines, Applications development, SDK, SyncML, Sim toolkit, SMS/MMS

Texts:

1. A Guide to Wireless Engineering Body of knowledge(WEBOK), IEEE publications, Wiley, ISBN 978-0-470-4066-9, 2009

2. Andrea Goldsmith, Wireless Communication, Cambridge University Press

3. D. Milojicic, F Douglas and R. Wheeler(Editors), Mobility, Processes, Computers and Agents, Addison Wesley, 1999

References:

1. Theodore Rappaport, ―Wireless Communications, principles and Practices, 2nd Edition, Pearson.163

2. C.S.R. Murthy, ―Ad-hoc Wireless Networks: Architecture and Protocols‖, Pearson Education.

3. Jochen Schiller, Mobile Communication, Second Edition, Pearson Education.

ME 650 Mini Project Work