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

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Proposed Course Code</th>
<th>Course</th>
<th>Contact Hours/week</th>
<th>Credits</th>
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<tr>
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<tr>
<td>1</td>
<td>AM 607</td>
<td>Mathematics for Engineers</td>
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<tr>
<td>2</td>
<td>CE 696</td>
<td>Artificial Intelligence and Expert Systems</td>
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<tr>
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<td>EE 666</td>
<td>Introduction to Electronic Systems</td>
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<td>EE 664</td>
<td>Inertial Sensors and Systems</td>
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<td>5</td>
<td>ME 626</td>
<td>Introduction to Robotics</td>
<td>3</td>
<td>0</td>
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<td>6</td>
<td>ME 627</td>
<td>Mechatronics</td>
<td>3</td>
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<td>Robotics Lab</td>
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*Practice school (optional) of 4 weeks during summer vacation*

### Semester II

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<td>Robotic Control</td>
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<td>ME 628</td>
<td>Robot Kinematics and Dynamics</td>
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<td>5</td>
<td>EE 667</td>
<td>Microcontrollers and Embedded systems</td>
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<td>6</td>
<td>ME 638</td>
<td>Field &amp; Service Robots</td>
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<td>Scientific/Engg. Practices and Skills</td>
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### Semester III

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# Semester IV

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<tr>
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## List of Electives

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<tr>
<td>1</td>
<td>AE 612</td>
<td>Nonlinear and Robust Control</td>
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<td>2</td>
<td>AE 617</td>
<td>Introduction to UAVs</td>
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<td>3</td>
<td>AM 625</td>
<td>Digital Image Processing</td>
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<td>4</td>
<td>CE 691</td>
<td>Secure Wireless Sensor Network</td>
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<td>5</td>
<td>CE 697</td>
<td>Robot Programming</td>
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<td>6</td>
<td>CE 698</td>
<td>Computer Graphics</td>
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<td>7</td>
<td>EE 604</td>
<td>Digital communication</td>
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<td>8</td>
<td>EE 613</td>
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<td>9</td>
<td>EE 618</td>
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<td>10</td>
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<td>11</td>
<td>ME 609</td>
<td>Mechanical Vibrations</td>
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<td>12</td>
<td>ME 629</td>
<td>Industrial Automation</td>
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<td>13</td>
<td>ME 635</td>
<td>CAD/CAM</td>
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<td>Flexible Manufacturing Systems</td>
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<td>ME 650</td>
<td>Mini Project Work</td>
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<td>Systems Engineering</td>
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<td>17</td>
<td>AP 610</td>
<td>Nanotechnology</td>
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<tr>
<td>18</td>
<td>EE 607</td>
<td>Advanced Wireless Communication</td>
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<tr>
<td>19</td>
<td>EE 622</td>
<td>Inertial Navigation System</td>
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Initial Value Problems for Ordinary Differential Equations: Euler, Modified Euler, Runge-Kutta methods, multi-step methods, predictor and corrector methods, stability and convergence analysis.


Text/References


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

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

Introduction:


Introduction to Digital communication and wireless communication

Introduction to Digital signal processing and image processing.

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
6. Millman & Halkias: Basic Electronic Principles; TMH.
9. Millman & Halkias – Integrated Electronics, Tata McG
10. Handbook of Modern Sensors by Fraden

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


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.


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

Reference Books:


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


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

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:


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

Introduction to feedback system, Mathematical modeling: Transfer functions; Block diagrams; Time domain analysis; Frequency Domain 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


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.


Text/References:


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


Texts:
1. ARM System-on-Chip Architecture (2nd Edition) Steve Furber
2. Real-time digital signal processing: Based on the TMS320C6000, Nasser Kehtarnavaz
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
Reference books:

**ELECTIVES**

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

**Texts/ References:**

**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:**
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.


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
6. Pattern Recognition, Applications to Large Data-Set Problems, 1984, Sing-Tze Bow, Marcel Dekker.
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:


**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:**


**CE 698 Computer Graphics** 3-0-3

Introduction, OpenGL®, Geometry

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


EE604 Digital Communication 3-0-3


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-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:**

**Reference books:**

**EE613 Electronic Warfare 3-0-3**

Unit-1: Introduction to Electronic Warfare:

UNIT-2: Electronic Support Measures:

UNIT-3: Electronic Counter Measures:

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

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
4. Introduction to Electronic Warfare 1984, Schleher De, Artech House

Reference Books:


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:

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:


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:


Data convetors interfacing:

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

Wireless and gps interfacing

Case study:

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

Text Books:


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:

**Reference Books:**

**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.


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


ME 635 CAD/CAM 3-0-3


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


Text/Reference

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.


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:


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:


2. Benjamin, A. Balachard and Walter, J Fabrycky, System Engineering and Analysis, 3rd ED., Prentice Hall International Series, Industrial & System Engineering
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


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.


Text/References
2. Introduction to Nanotechnology, Charles Poole Jr and Frank J Owens, Wiley India, New Delhi (2006)

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 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:**

**References:**