UNIVERSITY OF KALYANI

COURSE WORK SYLLABUS

for

Degree of Doctoral

on

Engineering

Department of Engineering and Technological Studies

Ph.D. Course Work Syllabus

Sl.No.	Paper Code	Paper
1.	PHD_DETS101	Research Methodology and Computer Application
Subject Up-gradation (on Recent Developments)		
1.	PHD_DETS102	Antenna and FSS
2.	PHD_DETS103	Soft Computing
3.	PHD_DETS104	Data Warehousing and Data Mining
4.	PHD_DETS105	Parallel Computing
5.	PHD_DETS106	Quantum Dot and Nano Computing Systems
6.	PHD_DETS107	Composite Materials
7.	PHD_DETS108	Engineering Tribology
8.	PHD_DETS109	Robotics
9.	PHD_DETS110	Image Processing

Subject : RESEARCH METHODOLOGY AND COMPUTER APPLICATION
Paper Code : PHD_DETS101 Full Marks : 100

Sl. No.	Details of the lesson
1.	Research Methodology : An Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing how Research is Done, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Defining the Research Problem, What is a Research Problem?, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, Research Design, Meaning of Research Design, Need for Research Design, Features of a Good Design.
2.	Data Collection and Analysis : Important Concepts Relating to Data Collection, Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method, Processing and Analysis of Data, Processing Operations, Some Problems in Processing, Elements/Types of Analysis.
3.	Statistics in Research : Measures of Central Tendency— Mean, Mode, Median, Quartiles; Measures of Dispersion— Range, Mean Deviation, Standard Deviation; Measures of Asymmetry— Skewness and Kurtosis; Measures of Relationship— Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Rank Correlation; Association in Case of Attributes, Chi-square Test— Chi-square as a Test for Comparing Variance, Chi-square as a Non-parametric Test, Conditions for the Application of Chi-square Test, Steps Involved in Applying Chi-square Test; Alternative Formula— Yates Correction, Conversion of Chi-square into Phi Coefficient, Conversion of Chi-square into Coefficient by Contingency, Important Characteristics of Chi-square Test, Caution in Using Chi-square Test; Analysis of Variance and Covariance– Analysis of Variance (ANOVA), Definition ANOVA, In Latin-square Design, Analysis of Co-variance (ANOCOVA), ANOCOVA Technique, Assumptions in ANOCOVA.
4.	Interpretation, Presentation and Report Writing: Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of reports, Oral Presentation, Mechanics of Writing a Research report, Precautions for Writing Research Reports.
5.	Software Concepts: Types of Software: System Software, Utility Software and Application software. System Software: Operating System, Language Compilers, Interpreters and Assembler, Operating System: Need of operating systems, Functions of Operating System Types of operating system. Utility Software: Compression tools, Anti Virus, file Management tools and Disk Management tolls: Application Software as a tool: Word Processor, Presentation Tool, Spreadsheet Package, Database Management System. Windows : General features, elements of Desktop – Taskbar, Icon, Start button, Shortcuts, folder, Recycle Bin, My Computer, Start Menu: Program, Documents, Settings, Find/Search, help, run, Shut Down/Logoff, Customization of Taskbar, Start menu display properties (Wallpaper Front Settings, Color Settings, Screen Savers): Program Menu: Accessories – Calculator, Notepad, paint, Word pad, media Player, Volume Controller): Internet Browsers – Mozilla Firefox, Internet Explorer, Netscape Navigator. Control Panel: Add new hardware; Add new software, Printer Installation, Date/Time, Mouse and Regional Settings. Documentation Purpose of using word processing software, opening a new/existing document, closing a document, typing in a document, saving a document, print preview, printing a document, setting up of page as per the specifications, selecting a portion of document, copying selected text, cutting selected text, pasting selected text; changing font, size, color of text; Inserting symbol; Formatting: Alignment – Left, right, Center, Justification Introduction to Open Office, IBM SPSS, LaTeX.

Recommended Books:

1.	"Research Methodology— Methods and Ttechniques", C.R. Kothari, New Age Int.
2.	"Research Methodology", R. Panneerselvam, PHI
3.	"Research Methodology", M. Gupta nad D. Gupta, PHI
4.	

Subject : ANTENNA AND FSS
Paper Code : PHD_DETS 102 Full Marks : 100

Sl. No.	Details of the lesson
1.	**Antenna –** Introduction – Types of Antennas – Radio Mechanism – Current Distribution on a Thin Wire Antenna – Historical Advancement.
2.	**Fundamental Parameters of Antennas**-Introduction-Radiation Pattern-Radiation Power Density-Radiation Intensity-Beamwidth-Directivity-Numerical Techniques Antenna Efficiency-Gain-Beam Efficiency-Bandwidth-Polarization-Input Impedance-Antenna Radiation Efficiency-Antenna Vector Transmission Equation and Rader range Equation-Antenna Temperature
3.	**Arrays: Linear, Planar, and Circular**-Introduction-Two-Element Array-N-Element Linear Array, Uniform Amplitude and Spacing- N-Element Linear Array: Directivity _Design Procedure- N-Element Linear Array: Three-Dimensional Characteristics. Rectangular-to-Polar Graphical Solution-N-Element Linear Array: Uniform Spacing, Non Uniform Amplitude- Super Directivity_planner Array-Design Consideration-Circular Array
4.	**Microstrip Antennas**-Introduction-Rectangular Patch-Circular patch –Quality Factor , Bandwidth and efficiency _ input impedance –Coupling –circular polarization –Arrays and feed network
5.	**Antenna Measurements** –Introduction – Antenna Ranges –Radiation Patterns –gain measurements –directivity measurements –radiation efficiency – impedance measurements –current measurements –polarization measurements –scale model measurements
6.	**Frequency Selective Surfaces** –General Overview –what is a periodic surface ?-complimentary arrays –passive versus active arrays –dipole versus slot arrays –a little history with physical insight – how do we "shape " the resonant curve –cascading periodic surfaces without dielectrics -single periodic surface with dielectric slabs –real hybrid periodic structures –application of periodic structures –hybrid Radomes –band-stop filters –Dichroic Sub reflectors Dichroic main reflectors – circuit analog absorbers Meander line polarizers -grating lobes
7.	**Element Types** –Introduction –centre connected or N-poles –"Gangnusters" surface –unloaded Tripole array –anchor element –Jerusalem Cross –square spiral elements –loop types –four legged loaded element –three legged loaded element –hexagon element -solid interior types –combination elements –some common misconceptions about elements –array versus element effect-bandwidth versus width of elements –comparison of elements
8.	**Evaluating Periodic Structure** –Introduction –single infinite case –double infinite case
9.	**Spectral Expansion of One-And Two –Dimensional periodic structures** –introduction –the vector potential dA_q from a single infinite column array of Hertzian elements with arbitrary orientation –vector potential dA for a double infinite array of Hertzian elements with arbitrary orientation –rectangular grid –skewed grid -vector Field dH(R) and dE(R) for a double infinite array of - Hertzian elements with arbitrary orientation –physical interpretation –vector field for a double infinite array of elements given current distribution and arbitrary orientation- Induced Voltages in a Linear Antenna- By a Single Plane Wave – By a Plane Wave Spectrum – Real Space-Positive Real – Imaginary Space-Negative Imaginary – Region II – Self-Impedance of a Single Element and of Arrays – Planar Elements of Arbitrary Shape – Total Radiated Field from an Array with Elements – Interpretation of Plane Wave Expansion – Current Distribution –Concept of Unit Cells – Length of Element Segments
10.	**Band- Pass Filter Designs** – Introduction- Modeling of an N- Layered Hybrid Radome – Determination of the Transmission Co-efficient for an N- Layered Hybrid Radome – Determination of the Current Induced in the First Array by the Incident Determination of the Slot Voltages Determination of the Transmitted Field – Analysis of the Hybrid Radome – Symmetric Hybrid Radome – Non-symmetric Hybrid Radome – N=1 : Monoplanar Symmetric Hybrid Radome –N=2 : Biplanar Symmetric Radome – N= 3:Triplanar Symmetric Hybrid Radome – Multilayered Cases – "Honeycomb" and Thick screen Radome – Honeycomb Panel – Thick Screen – Reflection : Image Lobes – Registration Sensitivity – Nuebbers' Anomaly – Common misconceptions about the design of Hybrid Radome _ Choice of Elements – Dielectric Profile – Inter- element spacing – Optimization – Thick Screen Radomes – Specific Process – Receive Transmit Dipoles Connected via

	Cables Mutual Admittance Practically of the Designs – Biplanar vs. Multilayered Designs – Accuracy of the Analysis
11.	**Band- Stop and Dichroic Filter Design** – Introduction – How to Calculate the Scattering from N Arrays of Dipoles in a Stratified Medium – Choice of Element type – Choice of Array Separation : Array Interface Nulls – Choice of Dielectric between Arrays – Matching in the Bandpass Region – Optimizing the Bandpass Transmission without use of Separate Matching Sections – Designing a Maching Section for a Bandpass Frequencies – Extending the Upper Frequency – Effect of Staggered Tuning – Conclusion for Bandstop Filter Design with Broad Bandwidth – Bandstop Filter with Narrow Bandwidth – Choice of Element – Choice of Dielectric Profile – Calculated Reflection and Transmission Curves – Optimization of Microstrip Antenna and FSS
12.	**Literature Survey** – Will be supervised by Supervisor

Recommended Books:

1.	
2.	
3.	

Subject : SOFT COMPUTING
Paper Code : PHD_DETS103 Full Marks : 100

Sl. No.	Details of the lesson
1.	Introduction to Evolutionary Computation: Biological and artificial evolution, Evolutionary computation and IA. GA— Recombination/Crossover for strings– one-point, multi-point-uniform crossover operators, Mutation for strings, bit-flipping, Recombination/Crossover and mutation rates, Recombination for real-valued representations, Fitness proportional selection and fitness scaling, Ranking methods. Major steps of genetic programming, functional and terminal sets, Initialization-crossover-mutation fitness evaluation, Search operators on tree.
2.	Fuzzy Set Theory: Introduction to Fuzzy Sets, Basic Definition and Terminology, Set-theoretic Operations, Member Function Formulation, Fuzzy Rules and Fuzzy Reasoning, Extension Principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning, Fuzzy Inference Systems, Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models
3.	Neural Networks: Supervised Learning Neural Networks, Perceptrons, Backpropagation Mutilayer Perceptrons, Radial Basis Function Networks, Unsupervised Learning Neural Networks, Competitive Learning Networks, Hopfield Network, Kohonen Self-Organizing Networks.
4.	Neuro Fuzzy Modeling: Adaptive Neuro-Fuzzy Inference System, Architecture, Hybrid Learning Algorithm, Learning Methods that Cross-fertilize ANFIS and RBFN.
5.	Application of Computational Intelligence: Printed Character Recognition, Inverse Kinematics Problems, Automobile Fuel Efficiency Prediction, Soft, Computing for Color Recipe Prediction.

Recommended Books:

1.	"Neuro-Fuzzy and Soft Computing", J.S.R. Jang and C.T. Sun, PHI.
2.	"Genetic Algorithms: Search, Optimization and Machine Learning", Davis E. Goldberg, Addison Wesley, N.Y.
3.	"Neural Networks, Fuzzy Logic and Genetic Algorithms", S. Rajasekaran and G.A.V.Pai, PHI.

Subject : DATA WAREHOUSING AND DATA MINING
Paper Code : PHD_DETS104 Full Marks : 100

Sl. No.	Details of the lesson
1.	Introduction: Data warehousing, Definitions and Characteristics, Multi-dimensional Data model, Warehouse schema.
2.	Data Marts: Data marts, Types of Data Marts, Loading a Data Mart, Metadata, Data Model, Maintenance, Nature of Data, Software Components; External Data, Reference Data, Performance Issues, Monitoring Requirements and Security in a Data Mart.
3.	Online Analytical Processing : OLTP and OLAP systems, Data Modelling, LAP tools, State of the market, Arbour Essbase web, Micro strategy DSS web, Brio Technology, Star Schema for Multi Dimensional view, Snowflake Schema; OLAP Tools.
4.	Developing a Data Warehousing: Building of a Data Warehousing, Architectural strategies & Organizational Issues, Design Considerations, Data Content, Distribution of Data, Tools for Data Warehousing.
5.	Data Mining: Definitions; KDD(Knowledge Discovery database) versus Data Mining; DBMS versus Data Mining, Data Mining Techniques; Issues and challenges; Applications of Data Warehousing & Data mining in Government.
6.	Association Rules: A Priori Algorithm, Partition Algorithm, Dynamic Inset Counting Algorithm, FP – tree Growth Algorithm; Generalized Association Rule.
7.	Clustering Techniques: Clustering Paradigm, Partition Algorithms, CLARA, CLARANS; Hierarchical Clustering, DBSCAN, BIRCH, CURE; Categorical Clustering, STIRR, ROCK, CACTUS.
8.	Decision Trees: Tree Construction Principle, Best Split, Splitting Indices, Splitting Criteria, Decision Tree construction with Presorting.
9.	Web Mining: Web content Mining, Web Structure Mining, Web Usage Mining, Text Mining.
10.	Temporal and Spatial Data Mining: Basic concepts of temporal data Mining, The GSP algorithm, SPADE, SPIRIT, WUM.

Recommended Books:

1.	"Data Warehousing –Concepts, Techniques, Products, Application", Prabhu; PHI.
2.	"Data Mining Techniques", A. K. Pujari, Universities Press.
3.	"Data Warehousing, Data Mining and OLAP", Alex Berson and Stephen J Smith, TMH.
4.	"Data Warehousing in the Real World", Anahory, Pearson Education.
5.	"Data Mining Introductory & Advanced Topic" Dunham, Pearson Education.

Subject : PARALLEL COMPUTING
Paper Code : PHD_DETS105 Full Marks : 100

Sl. No.	Details of the lesson
1.	The need for High Performance Computing , Classification of Parallel Machines– SISD, MISD, SIMD, MIMD, Fundamentals of Inter processor Communication , Shared Memory Basics– EREW, CREW, ERCW, CRCW;
2.	Interconnection Networks - All-to-All, Mesh, Rings, Hypercube, Shuffle Exchange, Cube Connected Cycles:
3.	Parallel Algorithm Design; Performance and scalability;
4.	Algorithms for array processors: Sum, prefix computation, matrix multiplication; Parallel sorting: odd-even transposition sorting, odd-even merging, enumeration sorting, bitonic sorting, odd-even merging network
5.	Parallel numerical algorithms; Routing algorithms; Communication algorithms: One-to-all, all-to-one, all-to-all, Multiprocessor systems; Point-to-point communication
6.	Faults, errors and fault models, Fault tolerance, Fault tolerant routing.

Recommended Books:

1.	"Parallel Computing - Theory and Practice", Quinm , Michael J, TMH
2.	"Scalable Parallel Computing", Kai Hwang & Zhiwei Xu, Mcgraw Hill.
3.	
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5.	

Subject : QUANTUM DOT AND NANO COMPUTING SYSTEM
Paper Code : PHD_DETS106 Full Marks : 100

Sl. No.	Details of the lesson
1.	Introduction: Recent past, the present scenario of Computing and its challenges, Future, Overview of basic Nano electronics.
2.	Quantum Mechanical Tunnel Devices: Overview of current research in nano-scale electronics and devices.
3.	Semiconductor and Device: Photonic Device and Materials, CMOS Device, Limit of CMOS technology-Scaling Theory. Quantum Dots & Quantum wires.
4.	Quantum computing: Basics and examples: introduction, axioms, quantum states and notation, unitaries, Measurement, Quantum circuits: classical reversible circuits, quantum circuits, universality.
5.	Quantum DOT cellular Automata (QCA): Introduction to nano-electronic and nano-computers, Quantum DOT cellular Automata (QCA), molecular circuits, Nano-computer Architecture.
6.	Defect analysis and Reliability: purpose of defect analysis in nano computing and Challenges. Reliability measurement in nano scale computing. Different soft computing tool for reliability analysis like Bayesian Network, Neural Networ

Recommended Books:

1.	"Quantum -dot Devices and Quantum-dot Cellular automata" by Wolfgang Prodog, Elsevier Science.
2.	"Electronic Transport in Quantum dot Cellular Automata", Leo P. Kouwenhoven
3.	"Quantum-dot Cellular Automata, Theory, Experimentation and Prospects" M. Macucci
4.	"Probabilistic Modeling of Quantum-dot Cellular Automata", Saket Rivastava, PhD dissertation
5.	"Quantum Computation: Theory and Implementation", Edward Stuart Boyden

Subject : COMPOSITE MATERIALS
Paper Code : PHD_DETS107 Full Marks : 100

Sl. No.	Details of the lesson
1.	INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS & MANUFACTURING Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices. Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness. Manufacturing: Bag Moulding – Compression Moulding – Pultrusion – Filament Winding – Other Manufacturing Processes
2.	FLAT PLATE LAMINATE CONSTITUTE EQUATIONS Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.
3.	LAMINA STRENGTH ANALYSIS Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure.
4.	THERMAL ANALYSIS Assumption of Constant C.T.E's. Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's. C.T.E's for special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates, Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates
5.	ANALYSIS OF LAMINATED FLAT PLATES Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies

Recommended Books:

1.	Gibson, R.F., Principles of Composite Material Mechanics, McGraw-Hill, 1994, Second Edition - CRC press in progress.
2.	Hyer, M.W., "Stress Analysis of Fiber – Reinforced Composite Materials", McGraw- Hill, 1998
3.	Issac M. Daniel and Ori Ishai, "Engineering Mechanics of Composite Materials", Oxford University Press-2006, First Indian Edition - 2007
4.	Mallick, P.K., Fiber –"Reinforced Composites: Materials, Manufacturing and Design", Maneel Dekker Inc, 1993.
5.	Halpin, J.C., "Primer on Composite Materials, Analysis", Techomic Publishing Co., 1984.
6.	Agarwal, B.D., and Broutman L.J., "Analysis and Performance of Fiber Composites", John Wiley and Sons, New York, 1990.
7.	Mallick, P.K. and Newman, S., (edition), "Composite Materials Technology: Processes and Properties", Hansen Publisher, Munish, 1990.

Subject : ENGINEERING TRIBOLOGY
Paper Code : PHD_DETS108 Full Marks : 100

Sl. No.	Details of the lesson
1.	**Introduction to Tribology:** Tribology in design, Tribology in industry, Economic aspects of Tribology, Lubrication— Basic modes of lubrication; Lubricants— Classification, Properties of lubricants— Physical and chemical; Additives— Requirement and types of additives, Oil emulsion. Bearings— Classification, Comparison between Sliding Contact and Rolling Contact Bearings Friction and Wear: Friction: Introduction, laws of friction, kinds of friction, causes of friction, friction measurement, theories of friction, effect of surface preparation. Wear: Types of wear, Various factors affecting wear, Measurement of wear, Wear between solids and liquids, Theories of wear.
2.	**Hydrodynamic lubrication:** Theory of hydrodynamic lubrication, Mechanism of pressure development in oil film; Basic differential equations— The Navier-Stokes equations, The generalized Reynold's equation; Incompressible Lubrication: Hydrodynamic journal bearings: One-dimensional bearings— Infinitely long journal bearing, Infinitely short journal bearing; Finite journal bearing; Hydrodynamic thrust bearing— Plane sliders, Curved sliders, Step bearings.
3.	**Hydrostatic and Squeeze film lubrication:** Hydrostatic lubrication: Introduction, Advantages and limitations; Plain journal bearings with incompressible lubrications— Laminar feeding, Turbulent feeding; Step Trust bearing with incompressible lubrications— Isothermal operation, Adiabatic operation. Squeeze film lubrication: Introduction, Advantages and limitations; Sliders and Rectangular plates, and Elliptical and Circular plates approaching a plane; Cyclic Squeeze film in a Journal bearing.
4.	**Elasto-hydrodynamic lubrication and Gas lubrication:** Elasto-hydrodynamic lubrication: Principle and application, Advantages and limitations; Pressure-viscosity term in Reynold's equation, Hertz theory. Ertel-Grubin Equation. Hydrodynamic Gas Lubrication: Introduction, Advantages and limitations, Applications; Infinitely long slider bearings— Plane inclined slider, Curved slider; Finite slider bearings— Plane inclined slider; Journal bearings— Infinitely long, Finite journal.

Recommended Books:

1.	"Theory of Hydrodynamic Lubrication", O. Pinkus and B. Sternlicht, Mc-Graw Hill.
2.	"Basic Lubrication Theory", A. Cameron, Wiley Eastern Ltd.
3.	"Introduction to Tribology and Bearings", B.C. Majumder, S.C. Chand & Co., New Delhi.
4.	"Theory and Practice of Lubrication for Engineers", D.D. Fuller, John Wiley & Sons
5.	"Principles of Tribology", J. Halling, McMillan Press
6.	"Fluid Film Lubrication: Theory and Design**",** Andras Z. Szeri, Cambridge University Press
7.	"Introduction to Tribology", Bharat Bhushan, John Wiley & Sons

Subject : ROBOTICS
Paper Code : PHD_DETS109 Full Marks : 100

Sl. No.	Details of the lesson
1.	**Introduction to robotics:** Introduction, Historical development of robot, types, classification and usage, Science and Technology of robots. kinematics and dynamics, degree of freedom, work space, manipulator trajectory planning and motion control.
2.	**Elements of robots— joints, links, actuators, and sensors:** Position and orientation of a rigid body, Homogeneous transformations, Representation of joints and links representation using D-H parameters; Different kinds of Actuators – Stepper, DC servo and brushless motors; Types of transmissions; Sensors— Purpose, Types— Internal and External sensors, Tachometers, Strain gauge based force-torque sensors, Vision sensors— Proximity and distance measuring sensors, Light sensors, Touch sensors— Pressure sensors and Thermal sensors.
3.	**Kinematics of robots:** Introduction, Rotation matrices, Euler angle and RPY representation, Homogeneous transformation matrices, Denavit-Hartenberg notation of linkages, Representation of absolute position and orientation in terms of joint parameters, Direct and inverse kinematics, Inverse orientation, Inverse locations, Singularities, Jacobian, Trajectory Planning: Joint interpolation, Task space interpolation, executing user specified tasks, sensor based motion planning: The Bug Algorithm, The Tangent Bug Algorithm, The Incremental Voronoi Graph.
4.	**Dynamics of serial and parallel robots:** Mass and inertia of links, Dynamic analysis using Lagrangian formulation and Newton-Euler formulations of RR and RP type planar robots, Independent joint control, PD and PID feedback, Actuator models, Nonlinearity of manipulator models, Cartesian control, Force feedback control, Hybrid control, Advanced topics in non-linear control of manipulators; Recursive dynamics.

Recommended Books:

1.	"Robotics and Control", R.K. Mittal and I.J. Nagrath, TMGH.
2.	"Robotics Dynamics and Control", M.K. Spong and M. Vidyasagar, John Wiley & Sons
3.	"Robotics, Control, Sensing, Vision and Intelligence", K.S. Fu, R.C. Gonzalez and C.S.G. Lee, TMGH
4.	"Principles of Robot Motion: Theory, Algorithms, and Implementations", H. Choset, K. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. Kavraki and S. Thurn, PHI
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Subject : IMAGE PROCESSING
Paper Code : PHD_DETS110 Full Marks : 100

Sl. No.	Details of the lesson
1.	**Digital Image Fundamentals:** A simple image model, Sampling and Quantization, Imaging Geometry, Digital Geometry, Image Acquisition Systems, Different types of digital images, Image processing steps.
2.	**Bilevel Image Processing:** Neighbour of pixels. Basic concepts of digital distances, distance transform, medial axis transform, component labeling, thinning, morpho-logical processing, extension to grey scale morphology.
3.	**Binarization and Segmentation of Grey level images:** Histogram of grey level images, Optimal thresholding using Bayesian classification, multilevel thresholding, Segmentation of grey level images, Water shade algorithm for segmenting grey level image. Region Oriented Segmentation - Basic Formulation, Region Growing by Pixel Aggregation, Region Splitting & Merging.
4.	**Detection of edges and lines in 2D images:** First order and second order edge operators, multi-scale edge detection, Canny's edge detection algorithm, Hough transform for detecting lines and curves, edge linking.
5.	**Images Enhancement:** Point processing, Contrast Enhancement -Linear & Nonlinear Stretching, Histogram Processing, Smoothing - Image Averaging, Spatial Filtering, Frequency domain filtering, multispectral image enhancement, image restoration.
6.	**Color Image Processing:** Color Representation, Laws of color matching, chromaticity diagram, color enhancement, color image segmentation, color edge detection. Processing based on Fourier Transformation, Properties of The Two Dimensional Fourier Transform, Discrete Fourier Transform, Discrete Cosine & Sine Transform
7.	**Image compression:** Lossy and lossless compression schemes, prediction based compression schemes, vector quantization, sub-band encoding schemes, JPEG compression standard, Fractal compression scheme, Wavelet compression scheme.
8.	**Image Registration and depth estimation:** Registration Algorithms, Stereo Imaging, Computation of disparity map.

Recommended Books

1.	"Digital Image Processing", Gonzalez and Woods, *Prentice-Hall India*.
2.	"Digital Image Processing and Analysis", B. Chanda and D. Dutta Majumder, *Prentice-Hall India*.