### COURSES FOR Ph. D. Program

#### Core Courses

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<th>CODE</th>
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<td>BIOMEMS and Nanotechnology:</td>
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#### Elective Courses

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COURSES FOR Ph. D. Program

EL 701 BIOMEMS AND NANOTECHNOLOGY: 3 0 0 0 3

Introduction to micro-electro mechanical systems (MEMS), MEMS sensor, intelligent sensors using MEMS: micro pump, micro cantilever beam; DNA Biosensors, multi-biosensors Lab-on-a chip, micromachining of bioanalytical devices, microarray Biosensors, nanosensors, nanoarrays and nanodevices, biochips; simulation technique for DNA nanodevices; E-nose, E-tongue; artificial auditory chips artificial vision chips, artificial audio/visual integrated systems based on brain information processing.

Books/References:


EL 702 INTELLIGENT SENSOR SYSTEMS 3 0 0 3 3

SENSORS: Primary sensing principles and measurement variable, Sensor performance characteristics and terminology.

INSTRUMENTATION: Transducer measurement circuits, Signal conditioning circuits, Data Conversion: DAC, ADC, Virtual instrumentation with LabVIEW
PATTERN ANALYSIS: Introduction to Statistical Pattern recognition Dimensionality reduction, Classification, Validation, Data analysis with MATLAB

INTELLIGENT SENSORS SYSTEMS: Structure, definitions and concepts, Advanced processing and control techniques, Smart Sensors, Case study: the “electronic nose”. The future of intelligent sensors systems.

Books/References:
1. R H Bishop, “Learning with LabVIEW”, Addison Wesley, 1999

EL 703 BIOMEDICAL SIGNAL PROCESSING


Digitization of Signal: Sampling theorem and A/D conversion: quantizing effects, aliasing artifacts in biomedical signals.

Discrete transforms: Discrete – time Fourier theorem, DFT and FFT; z-transform and properties.

Digital Filters: FIR and IIR filter, biomedical applications of digital filtering – removal power line interference from ECG data, reducing ECG artifact from EMG data.

ECG Pre-processing, wave form recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory, ECG compression, Evoked potential estimation.

EEG: evoked responses, averaging techniques, pattern recognition of alpha, beta, theta and delta waves in EEG waves, sleep stages, epilepsy detection.

EMG: wave pattern studies, biofeedback.

Books/References:
EL 704 BIOINSPIRED SYSTEMS AND ENGINEERING 3 0 0 3 3

Biologically inspired artificial devices: artificial Heart and circulatory assist devices, artificial lungs, artificial kidney, artificial cell, artificial muscle.

Artificial vision: Computer vision – word recognition, feature extraction based on biological visual system, stereo vision; speech recognition.

Biologically inspired systems: Robotic systems and devices, acoustical systems, computing system such as neural network, bioinspired exploration, bioinspired computer architectures.

Books/References:

BE 705 ADVANCED BIOELECTRONIC DEVICES 3 0 0 3 3

Metal: Oxide – Semiconductor (MOS), MOS structure, Model of operation, Metal Oxide Semiconductor Field effect Transistor (MOSFET).

Electrolyte – Insulator – Semiconductor (EIS): EIS Structure, Site binding Theory, Electrical double layer theory.

MOSFET based Bioelectronic devices: Biosensor overview, Ion Sensitive Field Effect Transistor (ISFET), Enzyme Field Effect Transistor (ENFET), Chemical Field Effect Transistor (CHEMFET), Reference Field Effect Transistor (REFET), Immune Field Effect Transistor (IMFET), Organic Thin Film Transistor (TFT), Cell-Based Biosensors & Sensors of Cell Metabolism, Light Addressable Potentiometric Sensors (LAPS), Interfacing of Biological
Systems with Electronic Systems, Non-conventional bioelectronic devices, conducting polymer based ISFET.

Modeling & Simulation: SPICE and Electrochemical models of ISFET & CHEMFET.

Books/References:

BE 706 NEUROENGINEERING

Biology of the neuron, biophysical description of the action potential, synapses, neuron as a threshold device, networks, neuroelectronics junctions, silicon neurons, SPICE modeling of Silicon neurons, Neural coding, models and methods, goal functions and time dependent learning rules, neural interfaces, EEG recording for brain computer interface applications, coding and decoding of neural information in bi-directional neural interfaces, Neuroengineering of mind: neural models of higher functions, large scale brain models, neural modeling and neural coding in the brain.

Books/References:

BE 707 BIOMEDICAL IMAGE PROCESSING

Medical imaging: X-ray imaging, computer assisted tomography magnetic resonance imaging, nuclear magnetic resonance imaging.

Image enhancement: Fundamental enhancement techniques, medical image enhancement with nonlinear filters.
Segmentation: Image segmentation basics, medical image segmentation by clustering, fuzzy clustering, segmentation by neural network, deformable modules and gradient vector flaw deformable modules, case studies of segmentation of brain heart etc.

Image reconstruction from projections: Principle of tomography, algebraic and Fourier domain reconstruction technique.

Image registration: Physical basics of spatial distortion in medical images, fundamental of registration; application of image registration for image guided surgery.


Books/References:
1. K. Shun, M F Insana, “Ultrasonic Imaging and Signal Processing”, SPIE
7. Stephen T C Wong, “Medical Image Database”, KAP
9. IssacBankman, “Handbook of Medical Imaging and Processing”.

BE 708 NEURO-FUZZY SYSTEMS 3 0 0 3 3


Neural Network: Introduction to neural network, neuron model, simple neuron & firing rules, neural architectures: Feed forward networks, Feed back networks, Radial Basis network, perceptions, adaptive networks, Learning methods, transfer functions, back propagation, the delta learning, clustering, applications of artificial neural networks(ANNs).


Books/References:
BE 709 ARTIFICIAL VISION

Introduction to vision, Basics of picture processing, Binary and grey scale images, Biological eyes compared to cameras and VLSI sensors; Types of camera for Machine Vision and their principles, different types of eyes; Optics; theoretical signal processing limits in eyes and cameras; the Sampling Theorem:

Colour Image Models: Colour models, colour representation, colour matching, histogram, colour difference measures, colour vision model and properties.

Preprocessing concepts – Digital image, Geometrical correction, Grey scale modification, Sharpening and smoothing the images.

Edge detection and line funding – Spatial differentiation, Extraction of line descriptions.

Softwares: Measurement and pattern recognition applications with examples – Two and three dimensional measurements, Fourier transform for pattern recognition applications, image operation studies, interfacing a robot with a vision system.

Books/References:
2. Oliver Faugeras, “Three Dimensional Computer Vision (Artificial Intelligence).”

EL 710 Analog and Digital Circuits

Overview of analog devices: Bipolar junction transistors, FET devices. Linear integrated devices: operational amplifiers and its characteristics, Op-amp applications, timer ICs. Digital systems: Review of Boolean algebra, logic technology, minimization techniques, combinational and sequential circuits, multiplexers, de-multiplexers and their applications, state machine models: FSM, ASM. Memory devices, clock generators, error detection and correction circuits, PLDs, FPGAs, CPLDs, ADCs, DACs. Power semiconductor devices: DIAC, TRIAC, BJT, MOSFET, IGBT, GTO, drive circuits, PSD protection circuits: snubbers.

Books/References:
1. Operating Amps and Linear Integrated Circuits by Ramakant A. Gayakwad (PHI)
2. Integrated Electronics: Analog and Digital Circuits and Systems. by Millman and Halkias (Tata McGraw Hill)
3. Digital Systems-Principles and Applications by R. J. Tocci and N. S. Widmer (PHI)

EL 711 Microwave Devices, Circuits and Measurements

Microwave transistor, microwave tunnel diode, varactor diode, Schottky diode, MESFET: Principle of operation, MOS structure, MOSFET microwave applications, Charge Coupled Devices (CCD), transferred electron devices: Gunn diode, LSA diode, modes of operation, microwave generation and amplification; avalanche effect devices: Read diode, IMPATT diode; klystron: velocity modulation process, bunching process, output power and beam loading; reflex klystron: power output and efficiency; traveling wave tubes, magnetron.

Microwave waveguide components: attenuators, phase shifters, matched loads, detectors and mounts, slotted-sections, E-plane tee, H-plane tee, hybrid tees, directional couplers, tuners, circulators and isolators, quarter wavelength transformer, multi-section transformer matching section; lumped planar components: capacitor, inductor and balun; power dividers, directional couplers, analysis of these components using the S-parameters, microwave planar filters, planar non-reciprocal devices, signal generators: fixed frequency, sweep frequency and synthesized frequency oscillators; frequency meters, VSWR meters, measurements of frequency, attenuation, VSWR and impedance; cavity measurements: Q-factor, bandwidth; dielectric and magnetic properties of materials: cavity and waveguide methods; measurements of power: calorimetric and microwave bridges; microwaves in process control instrumentation, microwave waste disposal, microwave in agriculture and medicine, hyperthermia etc., microwave heating, microwave absorbers.

Books/References:
1. Physics of Semiconductor Devices by S. M. Sze and K. K. Ng. (John Wiley)
2. Microwave Devices and Circuits by S. Y. Liao (Pearson Education)
3. Antennas by J. D. Kraus (McGraw Hill)

EL 712 Electromagnetic Theory and Antennas

Maxwell’s equations, electromagnetic radiation, plane waves in dielectric and conducting media, reflection and refraction of waves, transmission lines, smith chart and its applications, rectangular wave guide, rectangular cavity, modes in waveguides and cavities, dielectric filled wave guides, dielectric slab guide, surface guided waves, non-resonant dielectric guide, modal expansion of fields and its applications.

Antenna characteristics: radiation patterns, directive gain, side lobe, back lobe, polarization, co-polarization and cross polarization level, frequency reuse, beam width, input impedance, bandwidth, efficiency, antenna types: wire, loop and helix antennas, aperture antenna - slot, waveguide and horn antenna; parabolic reflector antenna, microstrip antenna: rectangular and
circular patch, feed for microstrip antennas: probe feed, microstrip line feed, aperture feed, electromagnetically fed microstrip patch; circularly polarized microstrip antennas, wide band and multi-frequency antennas, planar array, phased array and adaptive antenna, feed network of microstrip antenna array, antenna for mobile communication: handset antenna and base station antenna.

Books/References:
2. Microstrip Antenna Theory and Design by J. R. James, P. S. Hall and C. Wood (IEE Publication)

EL 713 Advanced Data Communication


Data Signaling: Encoding of Digital Data to Digital signal, Digital Data to Analog Signal, Analog Data to Analog signal and Analog Data to Digital Signal. Spread Spectrum Signaling, Data Communication Interface, Data Link control - stop & wait protocol, sliding window protocol, select & reject ARQ etc., multiplexing.


Books/References:
2. Murthy &Guruswamy: WDM Optical Networks.

EL 714 SIGNALS AND CIRCUITS

(Approved by 5th Academic Council held on 09–05- 08 Res. No.AC.05/2008/1/15)

1. Introduction to Signals and Systems: Signals and systems as seen in everyday life, and in various branches of engineering and science: electrical, mechanical, hydraulic, thermal, biomedical signals and systems as examples. Extracting the common essence and requirements of signal and system analysis from these examples.

2. Signal Characteristics: Energy and power signals, signal properties: periodicity, absolute integrability, Some special signals of importance: the unit step, the unit impulse,
the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals.


4. **The Laplace Transform:** Laplace transform of continuous time signals and systems: Laplace domain analysis, solution to differential equations and system behaviour.

5. **The Sampling Theorem:** Spectra of sampled signals, Reconstruction: ideal interpolator, zero-order hold, first – order hold, and so on. Aliasing and its effects. Relation between continuous and discrete time systems, basic digital circuits, A/D & D/A conversion.

6. **Applications of signals and systems theory:** Modulation and demodulation, filtering and Applications of signal and system theory: filtering-low-pass, high-pass, band-pass and band-elimination filters, examples like noise filtering and elimination of power line components from the ECG signals.

7. **Statistical signal analysis:** Statistical signal analysis, Probability, average, variance, standard deviation, correlation, time-series analysis.

**Books/References:**


**EL 715: Sparse Representations in Signal and Image Processing**

(Approved by 24th Academic Council meeting, held on 04/06/2015 vide Resolution No: AC.24/2015/1/3.1)
EL 715: Sparse Representations in Signal and Image Processing  

Course Contents:

Introduction: Sparse signal, Signal representations, Sparse representation of signals.

Sparse representation: Discrete cosine transforms, Discrete Fourier transform, Discrete wavelet transform, Dictionary learning for sparse representation.


Sparse Solution: Sparse Solution via Linear Programming, Under-determined systems of linear equations, $\ell^0$, $\ell^1$, $\ell^2$ and $\ell^p$ Solutions, Approximate sparse solution, Error correction via linear programming, Signal recovery from random projections.


Applications: Image Compression, Denoising, Super-resolution, Face Recognition, MRI, Feature Selection, Sparsity-Based Clustering, Missing, Incomplete, Corrupted Features.

Text Book:

References
As there is no specific text book for the course, the recommended references for this course may also include:
Course Contents:

Linear equations and matrices: Systems of linear equations, Homogeneous systems, Matrix algebra.

Vector Spaces: Real vector spaces, Euclidean space, Subspaces, Span, Range and Null space Linear dependence and Linear independence, Basis and Dimension, Rank of a Matrix, Rank Nullity theorem.

Orthogonality: Orthogonality, Inner product spaces, Orthogonality, Gram-Schmidt process, Norms, Orthonormal basis.

Eigenvalues and Eigenvectors: Eigenvalue-Eigenvector pairs, Characteristic equation, Eigenspaces and geometric multiplicity.

Linear Transformations: Kernel and range, Matrix of linear transformation, Operations on linear transformations, Dual Spaces.


Introduction to Convex Optimization: Convex sets, convex functions, Convexity, Conjugate function, conjugate sets, Hyperplanes, Norm-balls, Formulation of convex optimization problems.

Duality Theory: Weak and strong duality, Lagrangian dual function, KKT conditions.

Convex optimization algorithms: Barrier interior point method, Primal-dual interior point methods, Conjugate gradient-projection method.

Text Book:

Reference Books:
Course Contents:

Introduction: Digital image fundamentals, Brightness, Contrast and grey levels, Fundamentals steps in image processing.

Intensity Transformation and Spatial Filtering: Intensity Transformation, Histogram equalization, Histogram matching, Smoothening and Sharpening spatial filters.


Image Segmentation: Point, line detection, Edge detection, Boundary detection based techniques, Thresholding, Iterative thresholding, Region-based segmentation.

Morphological Image Processing: Erosion, Dilation, Opening, Closing, Hit-or-Miss Transform, Boundary Detection, Hole filling, Connected components, Convex hull, thinning, Thickening, Skeletons, Pruning, Morphological Reconstruction.

Text Books:

Reference Books:
Course Contents:


Feature Extraction: Geometric features - lines, circles, ellipses, Blobs, Edges - Canny; Line detectors, Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.

Shape Representation and Boundary descriptors: Shape from shading, Shape from monocular images, surface geometry, Boundary descriptors.

Object Recognition: System Components, Complexity of Object Recognition, Matching, Classification, Template Matching.

Image Formation Models: Monocular imaging system, Orthographic & Perspective Projection, Camera model and Camera calibration.

3D vision, Geometry: Methods for 3D vision, Projection schemes, Shape from shading, Photometric stereo, Shape from texture, Active range finding – Surface representations, 3D object recognition, and 3D reconstruction.

Motion Analysis: Regularization theory, Optical computation, Stereo Vision, Motion estimation, Structure from motion.

Text Books:

Reference Books: