This M-Tech programme is intended to generate trained academic and research personnel in the highly demanding, useful and emerging area of wireless networks. The programme includes core subjects from Wireless Communications, Computer Science, Computer networks, advanced topics in wireless communications, mobile computing, sensor networks, embedded systems, signal processing, multimedia systems and applications such as landslide detection, environmental monitoring, etc. Building on a very successful joint project called WINSOC with about a dozen international partners, this new M-Tech program was introduced with a view to strengthen the academic and research activities in this highly advanced topics: Wireless Networks and Applications.

Students, when they graduate, will be well trained to enter into a broad spectrum of industries such as computers, communication networks, earth sciences, environmental sciences, disaster management, health care, e-governance activities, bio and nano-technologies, VLSI and embedded systems, agriculture and chemical industries and strategic planning.

**CURRICULUM**

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**16WN601: Basics of Digital Signal Processing**  
2-0-1-3

Sampling and Reconstruction: Sampling Theorem, Anti-aliasing Prefilters, Sampling of Sinusoids, Analog Reconstruction and Aliasing, Spectra of Sampled Signals, Discrete-Time Fourier Transform, Spectrum Replication, Practical Antialiasing Prefilters — Basic Components
Lab: Implementation using MATLAB.

TEXT BOOKS/REFERENCES:

16MA622 PROBABILITY AND STATISTICAL INFERENCE

Introduction to Probability, conditional Probability, Bayes’ theorem: Random variables, Analysis of discrete and continuous random variables, Probability distributions, distribution functions, mean and variance of random variables, standard discrete and continuous distributions and their properties; Analysis of Joint Probability Distributions of discrete and continuous random variables, Two or more random variables, joint, marginal and conditional probability distributions, independence of random variables, Covariance and correlation, Linear functions of random variables, several functions of random variables; Point estimation of Parameters and Sampling distributions: Central limit theorem, General concepts of point estimation, Methods of point estimation, method of moments, method of maximum likelihood, Bayesian estimation of parameters, Interval estimation, Confidence interval for the mean and variance of a normal population, large sample confidence interval for population proportions; Hypothesis Testing, general concepts, tests on mean and variance of one and two normal populations, tests on population proportion, testing for goodness of fit and independence; Introduction to nonparametric statistics, sign test, Wilcoxon signed rank test, Wilcoxon rank sum test.

TEXT BOOKS/REFERENCES:

16WN602 ADVANCED COMPUTER NETWORKS


TEXT BOOKS/REFERENCES:
4. NFV architecture document from ETSI NFV.

TEXT BOOKS/REFERENCES:

16WN605          OBJECT ORIENTED PROGRAMMING          0-0-1-1

Java Atomic Data Types and Operators, Reference types, Date and time types, Enumerations, Selection statements (If else, switch), Iterations (while, for), Working with Arrays, Objects and Classes, Access modifiers and methods, Constructors, Inheritance and Polymorphism, Interfaces, Anonymous interfaces, Java Generics, Generic Collections (Lists, Sets, Maps), Exceptions, Java IO library (java.nio), Functional programming with Java 8 lambdas, Java 8 Streams, Multithreading in Java, Design patterns in Java (Singleton, Factory, Builder), UML Diagrams (Object, Activity, DataFlow), Agile methodologies, Test driven development, Unit testing in Java with JUnit and Netbeans

TEXT BOOKS/REFERENCES:

16WN621          FUNDAMENTALS OF WIRELESS COMMUNICATIONS          3-0-1-4
Antennas: Introduction to Antennas, Integration of antennas into systems, characteristic antenna quantities, Types of antennas: Antennas for mobile station, Antennas for base station.
Cellular Networks: Basic Concepts, Multiple Access Techniques: FDMA, TDMA, CDMA, OFDMA and SDMA; Wireless Link Improvement: Introduction to types of codes, Equalization Techniques, Diversity methods.
Research Paper Discussion and Presentation.
Wireless Communication Laboratory: Conduct experiments using Labview, C and Matlab.

TEXT BOOKS/REFERENCES:

16WN622 EMBEDDED SYSTEM DESIGN 3-0-1-4

Microcontroller fundamentals: ARM ASM programming and basic of C; IO Interfacing: LED and Switch; Design and Development Process: Architecture, Microarchitecture, Design, Implementation, Verification and Validation; Development Tools: Block Diagrams, Flow Charts, Call Graphs, Dataflow Graphs, Finite State Machines; The Parallel Interface: GPIO; The Serial Interface: UART; PLL programming; Timer: SysTick; Fixed Point; Software: Structs, Stacks and Recursion; Device Driver: Interfacing with an Hitachi HD44780 display; IO Synchronization; Interrupts; DAC: Music Synthesis and Music Playback; ADC: Real world interfacing and Data Acquisition.
Significant labs include prototypes of actual embedded systems, e.g., Traffic Light Controller (FSM), LCD Device Driver (Hitachi HD44780), Digital Piano (DAC, Interrupts), Digital Vernier Caliper (ADC, Interrupts, LCD), Distributed Data Acquisition (Interrupts, ADC, LCD, UART).
Capstone Design Project, A popular video game, e.g., Space Invaders, Connect-4, Pipe Dream, etc.

**TEXT BOOKS/REFERENCES:**

**16WN623 WIRELESS SENSOR NETWORKS 3-0-1-4**


- TinyOS Libraries: [http://www.tinyos.net/scoop/special/working_groups](http://www.tinyos.net/scoop/special/working_groups)
- NS2, NS3
- Qualnet

Creating hierarchical network, Implementation of Data aggregation, clustering and Time synchronization Algorithms, Indoor and outdoor testing of algorithms to study the effects on range, delay and data loss at different power levels, Integration of Sensor networks with Wireless LAN.

**TEXT BOOKS/REFERENCES:**

16WN624 MOBILE COMMUNICATION NETWORKS 2-0-1-3

Overview of the legacy second generation (2G) and third generation 3G networks including key developments in spectrum aspects. Review of the stake holders including Service Providers (SPs), product manufactures and regulatory bodies and interplay and context for MCN. Architecture of 4G networks from 3GPP and introduction to the physical layer and resource management. Key elements underpinning the network architecture including access stratum and non-access stratum, end to end security principles, network and UE procedures. Network design framework for call set-up/release, mobility management in idle mode and active mode (handover) and the dependency on the user experience. Introduction to network operations, management and support (BSS/OSS) including relevant use cases in diagnostics, life cycle of trouble shooting. Role of network planning and performance management and deployment of the networks for Quality of Support (QoS) and Quality of Experience (QoE). Network evolution towards Evolved Packet Core (EPC), Mobile Edge Computing (MEC) focus on architecture changes plus impact assessment. Overview of air interface upgrades, scalable air interface, Self Organising Networks (SON) and Heterogeneous Networks (HetNets). Wifi technology evolution to upcoming concepts pertaining to LTE in WiFi and introduction to candidate proposals in 5G [5].

TEXT BOOKS/REFERENCES:
5. Information from IEEE papers and various standardization bodies including IETF, ETSI, 3GPP, WiFi alliance and 5GPPP.

16WN625 RESEARCH LEARNING AND PROBLEM FORMULATION 0-0-1-1

Critical analysis of top rated research papers including at least one survey paper and one or two good journal paper in the broad areas such as Wireless Communication, Wireless Networks, Wireless Sensor Networks, Context Aware Systems, Participatory Sensing, Embedded Systems etc. Formulation and presentation of research proposals on selected topics.

16WN701 ADVANCED SIGNAL PROCESSING 3-0-0-3

Discrete-Time Bases and Filter Banks, Continuous-Time Bases and Wavelets, Over complete Expansions and Continuous Transforms, Sparse representation, Linear and non-linear approximation in various bases, Non-linear signal estimation, Multidimensional filter banks and wavelets, Multifractal analysis using Wavelets, Multiscale geometric representation
and processing, Compressed sensing, Multidimensional Transforms, Synthetic-aperture radar (SAR) Technology.

TEXT BOOKS/REFERENCES:

16WN702 DISTRIBUTED SYSTEMS 3-0-0-3


TEXT BOOKS/REFERENCES:

16WN703 WIRELESS LOCAL AREA NETWORKS 2-0-1-3

chipsets, 802.11 a/b/g PHY - Physical-Layer, Architecture, The Radio Link, FHSS, DSSS, OFDM, QAM, ERP; 802.11n : MIMO, Beam Forming, Channel Bonding, Block ACK, 802.11e QoS / WMM, 802.11s Mesh network, 802.11ac, 802.11ad, Performance Analysis, Mathematical Modeling and Analysis.


Advanced Topics: Long Range Wi-Fi, Li-Fi, Passive Wi-Fi, 802.11ah (HaLow), 802.11af (White-Fi), 802.11ax, 802.11ay

Lab: WLAN Lab based on the above topics will be conducted using Wireless routers, APs, Wi-Fi enabled smart phones, tablets and laptops and Long Range Wi-Fi base stations and CPEs as well as using QualNet simulation platform.

TEXT BOOKS/REFERENCES:

16WN704 ADVANCED EMBEDDED SYSTEMS 2-0-1-3


OS Principles: Threads, FIFO, Memory Management; Hardware Software Synchronization, Timing, Interrupts; Timer, PLL, PWM, Period and Frequency Measurement.


TEXTBOOKS/REFERENCES:
Short range networks: Introduction, Fundamentals of short range wireless; Bluetooth –
Introduction to Bluetooth, Bluetooth Technology, Bluetooth Topology, Bluetooth Networking,
Connection Establishment, Bluetooth 3.0, RFID Technology, NFC - Evolution of NFC, NFC as a
New Technology, NFC Essentials, Smart NFC Devices, General Architecture of NFC Enabled
Mobile Phones, NFC Operating Modes, Wireless Communication as a Communication Media for
NFC Technology; M2M - Machine to Machine Architecture and Protocols; Performance
Analysis.
Mobile OS: Android, iOS; Software Systems; Smartphone architecture and Software
development.

TEXT BOOKS/ REFERENCES:
3. Vedat Coskun, Kerem Ok and Busra Ozdenizci, “Near Field Communication (NFC): From
5. Vedat Coskun, Kerem Ok and Busra Ozdenizci, “Professional NFC Application Development

General concepts and terminology of measurement systems, transducer classification - Variable
resistance transducers, Inductive transducers, capacitive transducers, general input-output
configuration, static and dynamic characteristics of a measurement system, Statistical analysis of
measurement data. Standards and Calibration.
Smart materials and systems: Piezoelectric materials, Shape-memory materials, Electro-
Rheological (ER) fluids, Magneto-Rheological (MR) fluids.
MEMS: Introduction, emergence, devices and application, scaling issues, materials for MEMS,
Thin film deposition, lithography and etching. Bulk micro machining, surface micro machining
and LIGA process. MEMS devices, Engineering Mechanics for Micro System Design, Design of
Micro Pressure Sensor.
Introduction to Nanotechnology, Nano sensors, Molecular Nanotechnology, CNT Types, synthesis
and applications.
Introduction to Sensor networks: Advances in WSN-MEMS-Micro sensor, RF-MEMS-Micro
radios.

TEXT BOOKS/ REFERENCES:
2000.
Delhi 2002.

16WN707  MACHINE LEARNING  2-0-1-3

Role of learning in intelligent behavior, general structure of a learning system; learning from example; concept learning, Introduction to machine learning and machine learning applications, Supervised learning, Bayesian decision theory, Parametric methods, multivariate methods, dimensionality reduction, Support Vector Machine, clustering, nonparametric methods, decision trees, linear discrimination, Sparse Linear models, multilayer Perceptrons, local models, hidden Markov models, assessing and comparing classification algorithms, combining multiple learners, and reinforcement learning.

TEXT BOOKS/ REFERENCES:

16WN708  CODING AND INFORMATION THEORY  3-0-0-3

Discussion on Selected Journal Papers.

TEXT BOOKS/REFERENCES:

Research paper reading - IEEE Transactions and journal papers by Mihaela van der Schaar.

Mathematical Modeling and Analysis.

TEXT BOOKS/REFERENCES:

16WN710          ANTENNA ENGINEERING: THEORY AND DESIGN          2-0-1-3

Introduction, Antenna Basics, Antenna Arrays: Two element arrays, Multiplication of patterns, Linear Array with n -isotropic point sources of equal amplitude and spacing (Broadside, End fire Arrays), EFA with Increased Directivity, Scanning Arrays, N element linear array and directivity, Binomial Arrays- Uniform spacing and Non-uniform Amplitude.


TEXT BOOKS/REFERENCES:

16WN711 DISTRIBUTED NETWORK ALGORITHMS 2-0-1-3


TEXT BOOKS/REFERENCES:

16WN712 SECURITY IN WIRELESS NETWORKS 2-0-1-3

systems-2G/3G/4G, Telecom system and infrastructure attacks, Mobile app and OS security, PAN Security, IoT, NFC.

Lab: Wireless Security Lab based on the above topics will be conducted using Network Analyzers and QualNet simulation platform.

**TEXT BOOKS/REFERENCES:**

capacity, ergodic capacity; Capacity analysis of - Single user MIMO System with Full CSIT, Partial CSIT and Long term CSIT; Capacity Analysis of MIMO Fading Channel with long term and Short term channel Knowledge; Space-time Block Coded MIMO System, STTD, Alamouti Coding, Dominant mode Beamforming, ML, V-BLAST, D-BLAST- Performance analysis. Algorithms for MIMO. Spectral efficiency, link budget, coverage gain with MIMO. Limitations and implementation issues.


TEXT BOOKS/REFERENCES:

16WN715 BIG DATA AND APPLICATIONS 3-0-0-3

Introduction: Large databases and their evolution, Introduction to Data Science - Why Big Data? - Problems solved by Data Science - Data Science Process - Exploratory Data Analytics. Data Preparation: data munging - scraping - sampling - cleaning. Exploring and Analysis of Data - descriptive and inferential statistics, sampling, experimental design, parametric and non-parametric tests of difference, ordinary least squares regression, and general linear models; Data storage and management in order to be able to access data - especially big data - quickly and reliably during subsequent analysis - storage, search and retrieval systems for large scale structured and unstructured information systems.


TEXT BOOKS/ REFERENCES:

16WN716 ADAPTIVE SIGNAL PROCESSING 2-0-1-3

Wiener filter, Kalman Filter, Least Mean Square(LMS) and variants, LMS via DFT, DCT, Recursive Least Square(RLS), Fast transversal and Fast Lattice RLS, Convergence and tracking performance of adaptive filters; Applications of ASP, Spectral estimation, System identification, Channel equalization.

TEXT BOOKS/ REFERENCES:

16WN717 CLOUD COMPUTING AND INTERNET OF THINGS 2-0-1-3

Cloud Computing: Infrastructure as a Service (IaaS) providers - Google Compute Engine, Amazon AWS, Microsoft Azure; Cloud Database providers - Google Cloud SQL, Microsoft Cloud SQL Database; Cloud Storage providers: Google Drive API, Google Cloud Storage, Azure Blob Storage Platform as a Service (PaaS) providers for Web Rapid Application Development (RAD) - Google App Engine; Distributed Storage providers: Google Cloud Datastore, Azure tables; Distributed Computing providers and frameworks: Google Cloud Dataflow, Apache Spark.

Internet of things: Internet of Things definitions and frameworks, Internet of Things application examples, Fundamental IoT mechanisms and key technologies, Evolving IoT standards, Layer 1/2 connectivity: wireless technologies for the IoT; Applications of IoT in Environmental monitoring and Smart grid, Cloud solutions providers for IoT - Google Weave.

Laboratory: Deploying an application using an IaaS provider, Deploying an application using a PaaS provider, Writing applications using SQL vs NoSQL cloud storage solutions, Writing an application for Distributed Computing environments (Google Dataflow).

TEXT BOOKS/REFERENCES:

16MA704 RANDOM PROCESS AND QUEUEING MODELS 3-0-0-3

Queuing Models: Characteristics of Queuing Systems, Steady state solution of M/M/1 and M/M/C queuing models with Finite and Infinite Capacities, Stationary behavior of M/G/1.

TEXT BOOKS/REFERENCES:

16MA705 LINEAR ALGEBRA AND ITS APPLICATIONS 2-0-1-3


TEXT BOOKS/ REFERENCES:

16WN718 DETECTION AND ESTIMATION THEORY 2-0-1-3


TEXT BOOKS/ REFERENCES:

16MA706 COMPUTATIONAL OPTIMIZATION 2-0-1-3

Introduction- mathematical optimization, least-squares and linear programming, convex and nonlinear optimization, Convex sets, Steepest Descent, Newton's Method, Linear optimization,
Quadratic optimization, Generalized inequality constraints, Integer programming, Combinatorial optimization, Dynamic programming, Genetic Algorithms for optimization


TEXTBOOKS/REFERENCES:

16MA707GRAPH THEORY AND ITS APPLICATIONS IN WIRELESS NETWORKS 2-0-1-3

Graph Theory: An Introduction to Graph theory, Definition and examples, Subgraph, Complements and Graph Isomorphism, Vertex Degree: Euler Trials and Circuits, Planar Graphs, Hamilton Paths and Cycles, Probabilistic graph, Social Graphs, Applications in Social Networks, Graph Coloring and Chromatic Polynomials, Digraph, Dijkstra’s Shortest-Path Algorithm, maximal matching- perfect matching – k-factor graphs.


Algorithms and Applications: Shortest and longest path algorithm, Minimal and Maximal spanning tree algorithms, maximal matching algorithms, Coloring algorithms, Graph Partitioning algorithm.

Research Paper Discussion and Presentation on applied graph theory in wireless networks.

TEXT BOOKS/REFERENCES:

16WN797 LIVE-IN-LABS 0-0-1-1

AMRITA University has established live-in-labs at 100+ locations, mostly in rural areas spread across the length and breadth of India. Live-in-Labs© is an opportunity for students to live in a village environment so they can study problems first-hand in water, health, education, etc. and work together to devise solutions. Live-In-Labs will provide an experiential learning opportunity where each student can come and spend for 2 weeks to a semester in one of the live in labs based
on the area. They will become part of the interdisciplinary team of students and faculty drawn
from across the disciplines from all participating universities. The live-in-labs have varied focus
areas such as energy, water, healthcare, education, waste management, ICT for billion, skill
building etc.
During this process the students will share village life and observe and understand problems
encompassing health and hygiene, energy, water, waste, environment, etc., touching the villagers’
lives, and define projects that seek to address these problems, devise solutions, implement, test
and eventually demonstrate innovative solutions. One definitive achievement is that they will
receive a deeper understanding of challenges faced by emerging developing countries. This gives
the wonderful opportunity since emerging countries have the largest opportunity for new ideas,
innovative solutions etc.