# Information Booklet

# For

# Postgraduate Studies

## Institute of Information & Communication Technology

## Dhaka University of Engineering & Technology (DUET), Gazipur

# M.Sc/M.Engg

The Masters Degrees to be offered by the Institute of Information & Communication Technology (IICT) are as follows:
Master of Science in Information & Communication Technology abbreviated as M Sc. Engg. (ICT). (Thesis Based)

Master of Engineering in Information & Communication Technology abbreviated as M Engg. (ICT). (Project Based)

## ♦ Academic Requirements and Regulations

1. The minimum duration of M Sc. Engg. / M Engg. Program shall be three semesters and generally not more than 5 (five) Academic Years starting from the date of first registration. Each Academic Year shall consist of two semesters. The duration of a semester will be of minimum 13 (thirteen) weeks.

2. For the Degree of M Sc. Engg., a student must earn a minimum of 36 credit hours of which 18 credit hours shall be assigned for a Thesis.

3. For the Degree of M Engg., a student must earn a minimum of 36 credit hours of which 6 credit hours shall be assigned for a Project.

| **Courses** | **M.Sc Engg. Credits** | **M. Engg. Credits** |
|---|---|---|
| **Theory Courses** | 3 x 6 = 18 | 3 x 10 = 30 |
| **Thesis / Project** | 18 | 6 |
| **Total Credits =** | 36 | 36 |

# Syllabus for M Sc. Engg. /M Engg. (ICT)

| Course No. | Course Title | Credit |
|---|---|---|
| ICT 6000 | Thesis | 18 |
| ICT 6001 | Project | 6 |
| ICT 6101 | Research Methodology | 3 |
| ICT 6102 | ICT Project Management | 3 |
| ICT 6103 | ICT Basics and Programming | 3 |
| ICT 6104 | Graph Theory and Application | 3 |
| ICT 6105 | Advanced Algorithm and Optimization | 3 |
| ICT 6106 | Software Engineering | 3 |
| ICT 6107 | Software Quality Assurance | 3 |
| ICT 6201 | Advanced Database Management Systems | 3 |
| ICT 6202 | Big Data Analysis and Design | 3 |
| ICT 6203 | Advanced Information Theory and Coding | 3 |
| ICT 6204 | Information Retrieval | 3 |
| ICT 6205 | Distributed Systems | 3 |
| ICT 6206 | Smart Mobile Data Management | 3 |
| ICT 6301 | Cloud Computing | 3 |
| ICT 6302 | Fog Computing | 3 |
| ICT 6303 | Internet of Everything | 3 |
| ICT 6304 | ICT Advancement towards Industrial Revolution | 3 |
| ICT 6305 | Advanced Cyber Physical System | 3 |
| ICT 6306 | Bioinformatics Computing | 3 |
| ICT 6307 | Biomedical Image Processing | 3 |
| ICT 6401 | Intrusion Management and Ethical Hacking | 3 |
| ICT 6402 | Applied Cryptography | 3 |
| ICT 6403 | Internet and Cyber security | 3 |
| ICT 6501 | Computational Linguistics | 3 |

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|---|---|---|
| ICT 6502 | Statistical Machine Translation | 3 |
| ICT 6503 | Advanced Artificial Intelligence | 3 |
| ICT 6504 | Machine Learning | 3 |
| ICT 6505 | Automated Planning | 3 |
| ICT 6506 | Neuro-Fuzzy Systems | 3 |
| ICT 6601 | Speech Processing | 3 |
| ICT 6602 | Antennas and Propagation | 3 |
| ICT 6603 | Radar Engineering | 3 |
| ICT 6604 | Advanced Digital Signal Processing | 3 |
| ICT 6605 | Advanced VLSI Design and Testing | 3 |
| ICT 6606 | Reliable Computing System | 3 |
| ICT 6701 | Wireless Networks | 3 |
| ICT 6702 | Advanced Communication Engineering | 3 |
| ICT 6703 | Radio Frequency Technology | 3 |
| ICT 6704 | Advanced Telecommunication Network | 3 |
| ICT 6705 | Next Generation Mobile Communication | 3 |
| ICT 6706 | Broadband Wireless Communications | 3 |
| ICT 6707 | Smart Sensor Networking | 3 |
| ICT 6708 | Advanced Computer Network | 3 |
| ICT 6709 | Advanced Data Communications | 3 |
| ICT 6710 | Satellite and Navigation | 3 |
| ICT 6711 | Geographical Information System | 3 |
| ICT 6801 | Advanced Embedded System Design | 3 |
| ICT 6802 | Real Time Computing for Embedded System | 3 |
| ICT 6803 | Industrial Automation and Control | 3 |
| ICT 6804 | Advanced Computer Architecture | 3 |
| ICT 6805 | Advancement in Microprocessor Systems | 3 |
| ICT 6900 | Selected Topics in ICT | 3 |

**ICT 6101 Research Methodology 3 Credits**

Definition, Objective, Motivation, Types of Research, Criteria of Good Research. Research Problem, Selection of Problem, Necessity of defining the Problems, Techniques involves in defining the problem. Meaning of Research Design, need for research Design, Features of a Good Design, Different Design Approach. Sampling Design: Census and Sample Survey, Implications and steps of a Sample Design, Criteria of Selecting a
Sampling Procedure, Different Types of Sample Designs, how to Select a Random Sample, Random Sample from an infinite Universe, Complex Random Sampling Designs. Measurement in Research, Measurement Scales, Sources of Error in Measurement, Technique of Developing Measurement Tools. Collection of Primary Data, Observation Method, Interview Method, Collection of Secondary Data. Processing Operations, Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Relationship, Regression Analysis. Need for Sampling, Sampling Distributions, Central Limit Theorem, Sampling Theory, Concept of Standard Error, Estimation of Population Mean, Population Proportion, Sample Size and determination. Interpretation, Technique of Interpretation, Precautions in Interpretation, Steps in Writing Report, Types of Reports, and Precautions for Writing Research Reports.

**ICT 6102 ICT Project Management 3 Credits** Introduction to Project Management: ICT Project types, Project Management Initiation, The Project Manager, The Project Organization. Project Planning, Budgeting and Cost Estimation. Scheduling and Resource Allocation: CPM Method, Resource allocation Problem, Resource loading and Resource leveling, Constrained Resource
Scheduling, Multi-Project Scheduling and Resource allocation. Project Risk Management. Project Procurement Management. Project
Communication and Quality Management, Project Quality Control – Monitoring and Control and Standards. Project Stakeholder Management: Stakeholder influence, PSM Process and execution. Managing Contracts.

**ICT 6103 ICT Basics and Programming 3 Credits**

Computer Basics: Introduction to computations; history of computing devices; Computers; Major components of a computer; Hardware: processor, memory, I/O devices; Software: Operating system, application software; Report writing and Presentation; Basic architecture of a computer; Basic Information Technology; Number system: binary, octal, hexadecimal, binary arithmetic. Structured Programming Language: Identifier names, Variable, Type Quality, Storage Class Specification, Variable Initialization, Constants, Operators Single Character Input, Single Character Output, Entering Input Data, Writing Output Data, The Gets and Puts Function, Array, Functions, Single Dimension Array, Passing Single-Dimension Array to Function, Two-Dimensional Array, String. Object Oriented Programming Language: Philosophy of Object Oriented Programming (OOP); Advantages of OOP over structured programming; Encapsulation, classes and objects, access specifiers, static and non-static members; Constructors, Destructors and Copy
Constructors.

**ICT 6104 Graph Theory and Applications 3 Credits**

Graphs and Subgraph: Graphs and Simple Graphs, Graph Isomorphism, The Incidence and Adjacency Matrices, Subgraphs, Vertex Degrees, Paths and Connection, Cycles, Applications – The Shortest Path Problem, Sperner's Lemma. Trees: Cut Edges and Bonds, Cut Vertices, Cayley's Formula, Spanning trees, shortest paths, distances in graphs; Hamiltonian and Eulerian graphs, Travelling Salesman problem, Chinese Postman problem; Applications - The Connector Problem. Connectivity: vertex and edge connectivity, Menger’s theorem, Blocks, Applications-Construction of Reliable Communication Networks. Euler Tours, Hamilton Cycles, Applications-The Chinese Postman Problem, The Travelling Salesman Problem. Matchings: Coverings in Bipartite Graphs Perfect Matchings, Applications - The Personnel Assignment Problem, The Optimal Assignment Problem. Vertex Colorings: Chromatic Number, Brooks' Theorem, Hajos' Conjecture, Chromatic Polynomials, Girth and Chromatic Number, Applications - A Storage Problem. Planar Graphs: Plane and Planar Graphs, Dual Graphs, Euler's Formula, Bridges, Kuratowski’s

Theorem, Perfect graphs, The Five-Colour Theorem and the Four-Colour Conjecture, Nonhamiltonian Planar Graphs, Applications - A Planarity Algorithm. Networks: Flows, Cuts, The Max-Flow Min-Cut Theorem, Applications - Menger's Theorems, Feasible Flows.

**ICT 6105 Advanced Algorithm and Optimization 3 Credits**

Define Optimization Problems; The Simplex Algorithm; Duality; Computational Considerations for the Simplex Algorithm; The PrimalDual Algorithm; The Primal-Dual Algorithms for Max-Flow and Shortest Path: Ford-Fulkerson and Dijkstra; Primal-Dual Algorithms for Min-Cost Flow; Algorithms and Complexity; Efficient Algorithms for the MaxFlow Problem; Algorithms for Matching; Weighted Matching; Spanning tree and Matroids; Integer Linear Programming; Evolutionary optimization algorithms; Adaptive Genetic Algorithm; Bayesian statistics as optimization technique; Artificial neural network; Optimization methods for inverse problems; A Cutting-Plane Algorithm for Integer Linear Programs; NP-Complete Problems; More About NPCompleteness; Approximation Algorithms; Unconstrained non-linear optimization problems; Constrained nonlinear optimization problems; Multi objective optimization problems; Solving optimization problems using MATLAB.

**ICT 6106 Software Engineering 3 Credits**

Introduction, software life-cycle models, software requirements specification, formal requirements specification and verification - axiomatic and algebraic specifications, function-oriented software design, object-oriented design, UML, design patterns, user interface design, coding and unit testing, integration and systems testing, debugging techniques, software quality - SEI CMM and ISO-9001. Software reliability and fault-tolerance, software project planning, monitoring, and control, software maintenance, computer-aided software engineering (CASE), software reuse, component-based software development, extreme programming.

**ICT 6107 Software Quality Assurance 3 Credits**

Definition of Software Quality, Quality Dimensions, SQ Dilemma, Achieving Software Quality. Software Defects, Defect amplification and

removal, Review Metrics and their use, Informal Reviews, Formal technical reviews, Review reporting and record keeping. Elements of SQA, SQA Task, Goals and Metrics, Formal Approaches to SQA, Statistical SQA, Software Reliability, The ISO 9000 Quality Standards, The SQA Plan. The Strategic Approach for Software Testing, Verification and Validation, Organizing for Software Testing, Criteria for Completing of Testing, Strategic Issues. Testing Strategies for Conventional Software: Unit Testing, Integration Testing, Strategies for OOS, Testing in OO context, and Integration Testing in OO context, Strategies for Web Apps., Validation Testing, Alpha and Beta Testing. System Testing: Recovery Testing, Security Testing, Stress Testing, Performance Testing,
Deployment Testing, Art of Debugging. Testing Conventional Applications: White box testing, Basis Path Testing, Central Structure Testing, Black box Testing, Model Based Testing, Testing Client Server Architectures, Testing for Real Time Systems, Patterns for Software
Testing. Testing Object Oriented Applications: Testing OOA and OOD Models, Object Oriented Testing Strategies, Testing methods applicable at Classes, Interclass Test case Design, Test Derived from Behavior Models. Testing Web Applications: Content Testing, User Interface Testing, Component Level Testing, Navigation Testing, Configuration Testing, Security Testing, Performance Testing.

**ICT 6201 Advanced Database Management Systems 3 Credits**

Comparison between DBMS, RDBMS, Distributed and Centralized DB. Object Oriented Database; Data Model, Design, Languages; Object Relational Database: Complex data types, Querying with complex data types, Design; Distributed Database: Levels of distribution transparency, Translation of global queries to fragment queries, Optimization of access strategies, Management of distributed transactions, Concurrency control, Reliability, Administration; Parallel Database: Different types of parallelism, Design of parallel database; Multimedia Database Systems, Optimization of access strategies, Management of Multimedia Database Systems, Reliability; Database Wire-housing/Data mining: Basic Concepts and algorithms. Advanced SQL; Some applications using SQL. Integrity constraint; Relational database design; File organization and retrieval, file

indexing and hashing; Transaction manager; Concurrency controller; Recovery manager; Security system; Database administration; Transaction processing: Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability, resolving deadlock, distributed locking. Transaction management in multidatabase system, long duration transaction, high-performance transaction system. Advanced database management systems: distributed database, parallel database, data mining and warehousing, multimedia, objectoriented, object-relational, real-time database. Semi structured data.

**ICT 6202 Big Data Analysis and Design 3 Credits** Big Data Platform, Challenges of Conventional Systems, Intelligent data analysis, Nature of Data, Analytic Processes and Tools, Reporting. Mining data streams: Stream Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Stream, Counting Distinct Elements in a Stream, Estimating Moments, Counting Oneness in a Window, Decaying Window, Real time Analytics Platform Applications, Real Time Sentiment Analysis, Stock Market Predictions. Hadoop: History, Hadoop Distributed File System, Components of Hadoop Analysing the Data, Scaling Out, Hadoop Streaming, Design of HDFS, Java interfaces to HDFS Basics, developing a Map Reduce Application, Map Reduce Work, Anatomy of a Map Reduce Job, Failures, Job Scheduling, Shuffle and Sort, Task execution, Map Reduce Types and Formats, Map Reduce Features. Frameworks: Applications on Big Data Using Pig and Hive, Data processing operators in Pig, Hive services, HiveQL, Querying Data in Hive, Fundamentals of
HBase and Zoo Keeper, IBM Info Sphere Big Insights and Streams.
Predictive Analytics, Simple linear regression, Multiple linear regressions, Interpretation of regression coefficients. Visualizations, Visual data analysis techniques, interaction techniques, Systems and applications.

**ICT 6203 Advanced Information Theory and Coding 3 Credits**
Fundamental Limits in Information Theory: Measure of Information, Data Compaction, Discrete Memory less Channels, Relationship among different

Entropies, Mutual information, Channel Capacity, Symmetric noise structure BSC and BEC, Channel Coding Theorem, Differential Entropy and Mutual Information for Continuous Ensembles, Information Capacity Theorem, Rate Distortion Theory. Elements of Encoding: Source Coding: Instantaneous Codes, Source Coding Theorem, The Kraft Inequality and McMillan's Theorem, Average Length and Compact Codes, Shannon's Noiseless Coding Theorem, Fano Coding, Huffman Coding, Arithmetic Coding, Higher-order Modeling. Fundamentals of Channel Coding: Code Rate, Decoding Rules, Hamming Distance, Bounds on M, Maximal Codes and Perfect Codes, Error Probabilities,
Shannon's Fundamental Coding Theorem. Introduction to Algebra:
Groups, Ring, Vector space and Fields, Linear Spaces, Linear Spaces over Binary Fields, Construction of Galois field GF (2m), Basic Properties of Galois Field GF (2m), Codes Derived from Hadamard Matrices. Error Correcting Codes: Linear Block Codes, Syndrome and Error detection.
Cyclic Codes: Rings of Polynomials, Encoding and Decoding of Cyclic Codes and its Circuits, Goley Codes, Hamming Codes, Reed-Muller Codes. Burst Correcting Codes: Finite Fields, Irreducible Polynomials, Construction of Finite Fields, Bursts of Errors, Fire Codes, Minimum Polynomials, Bose-Chaudhuri-Hocquenghem Codes, Reed-Solomon Codes. Convolution Codes: Binary Convolution Codes, Decoding Convolution Codes, the Viterbi Algorithm, Sequential Decoding, Trellis Modulation, Turbo Codes.

**ICT 6204 Information Retrieval 3 Credits** Introduction to Information retrieval: Information retrieval process, Indexing, Information retrieval model, Boolean retrieval model. Dictionary and Postings: Tokenization, Stop words, Stemming, Inverted index, Skip pointers, Phrase queries. Tolerant Retrieval: Wild card queries, Permuterm index, Bigram index, Spelling correction, Edit distance, Jaccard coefficient, Soundex. Term Weighting and Vector Space Model: Wild card queries, Permuterm index, Bigram index, Spelling correction, Edit distance, Jaccard coefficient, Soundex. Evaluation: Precision, Recall, F-measure, E-measure, Normalized recall, Evaluation problems. Latent Semantic Indexing: Eigen vectors, Singular value decomposition, Low rank approximation, Problems with

Lexical Semantics. Query Expansion: Relevance feedback, Rocchio algorithm, Probabilistic relevance feedback, Query Expansion and its types, Query drift. Probabilistic Information Retrieval: Probabilistic relevance feedback, Probability ranking principle, Binary Independence Model, Bayesian network for text retrieval. XML Indexing and Search: Data vs. Text-centric XML, Text-Centric XML retrieval, Structural terms. Content Based Image Retrieval: Introduction to content Based Image retrieval, Challenges in Image retrieval, Image representation, Indexing and retrieving images, Relevance feedback.

**ICT 6205 Distributed Systems 3 Credits**

Introduction, Consistency - Classical synchronization + Go-style synchronization, Distributed File systems, Remote Procedure Calls, AFS, Coda, Callbacks. Time and Synchronization, Distributed Mutual Exclusion, Fault Tolerance: Detecting and Correcting Local Faults, RAID, Concurrency Control, Logging and Crash Recovery, Consistent hashing and name-by-hash, Consistent hashing and name-by-hash, Distributed File systems for MapReduce / HDFS, DNS and Content Delivery Networks, Peer-to-Peer, Virtual Machines, Byzantine Fault Tolerance, Security Protocols, Case Study - Anonymous Routing and TOR, Causally Consistent Wide-Area Replication. Distributed object systems, Retrieving and caching of distributed information, Distributed data replication and sharing, Performance Issues, Algorithms for Deadlock Detection, Concurrency Control, Networking Facilities and Resources Control and Management Methods in Network and Distributed Operating Systems, Collaborative Applications, Wide Area Network Computing, Agent Systems and Market Based Computing.

**ICT 6206 Smart Mobile Data Management 3 Credits**

Mobile Location Management: Registration and Paging, Two Tier Structure, Hierarchical Scheme, Caching, Forwarding Pointers, Replication, Personal Mobility, Distributed Location Management. Distributed Systems and Algorithms, Mobile Systems and Algorithms, Structuring Distributed Algorithms, Non-coordinator Systems, Exploiting Asymmetry of Two-Tier Model, Termination Detection. Data Access Issues

in Mobile Environment, Pull and Push Based Data Delivery, Dissemination in Mobile Environment, Comparison of Pull and Push Models, Classification of Data Delivery Models, Broadcast Disk,
Probabilistic Model of Broadcast, Inter Mezzo, File System for Connected Clients. Context-aware Infrastructures for Smart Environment: Terminology and Historical Prospective, Designing Context-aware Applications, Formal Modeling of Contexts, System Requirements, Middleware Architectures, Smart Applications.

**ICT 6301 Cloud Computing 3 Credits** Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models, Popular Cloud Stacks and Use Cases, Benefits, Risks, and Challenges of Cloud Computing, Economic Models and SLAs, Topics in Cloud Security. Cloud Infrastructure: Historical Perspective of Data Centers, SaaS, PaaS and IaaS. Datacenter Components: IT Equipment and Facilities. Design Considerations: Requirements, Power, Efficiency, & Redundancy, Power Calculations, PUE and Challenges in Cloud Data Centers, Cloud Management and Cloud Software Deployment Considerations. Virtualization (CPU, Memory, I/O). Case Study: Amazon EC2, Software Defined Networks (SDN), Software Defined Storage (SDS). Introduction to Storage, Systems Cloud Storage Concepts Distributed File Systems (HDFS, Ceph FS), Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB), Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph). Distributed Programming for the Cloud, Data-Parallel Analytics with Hadoop MapReduce (YARN), Iterative Data-Parallel Analytics with Apache Spark, Graph-Parallel Analytics with Graph Lab 2.0 (PowerGraph).

**ICT 6302 Fog Computing 3 Credits**

Fog Computing-Definition-Characteristics-Application Scenarios - Issues - Fog Computing and Internet of Things-Pros and Cons-Myths of Fog Computing -Need and Reasons for Fog Computing Fog Computing and Edge Computing-IoT, FOG, Cloud- Benefits. Working Procedure Performance Evaluation Components- Software Systems – ArchitectureModeling and Simulation –Challenges. Fog Protocols: Fog

Protocol-Fog Kit- Proximity Detection Protocols- DDS/RTPS computing protocols. Smart Management of Big Data-Smart Data-Structure of Smart Data- Smart Data Life Cycle-System Architecture-Multi-dimensional Payment
Plan- -Security and Privacy Issues-Multimedia Fog ComputingArchitecture-Deduplication-Hybrid Secure Deduplication-Security Challenges-Security Requirements. Wind Farm - Smart Traffic Light System, Wearable Sensing Devices, Wearable Event Device ,Wearable System, Demonstrations, Post Application Example, Event Applications Example.

**ICT 6303 Internet of Everything 3 Credits** Internet in General and Internet of Things: Layers, Protocols, Packets, Services, Performance Parameters of a Packet Network as well as Applications such as Web, Peer-to-peer, Sensor networks, and Multimedia. IoT Definitions: Overview, Applications, Potential and Challenges, and Architecture. IoT Protocols: HTTP, CoAP, MQTT,
AMQP, 6LoWPAN. IoT Data and the IoT Cloud Infrastructure. Performance and Security in IoT. IoT examples: Case Studies, e.g., Sensor Body-Area-Network and Control of a Smart Home.

**ICT 6304 ICT Advancement towards Industrial Revolution 3 Credits**
Introduction to Industry 4.0: The Various Industrial Revolutions, Digitalization and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, Comparison of Industry 4.0 Factory and Today's Factory. Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation. Road to Industry 4.0: Internet of Things (IoT) & Industrial Internet of Things
(IIoT) & Internet of Services, Smart Manufacturing, Smart Logistics, Smart Cities. Related Disciplines, System, Technologies for enabling Industry 4.0: Cyber physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Cyber Security. Role of data, information, knowledge and collaboration in future organizations: Resource-based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge in organizations, Cloud Computing

Basics, Cloud Computing and Industry 4.0. Business issues in Industry 4.0:Opportunities and Challenges, Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world.

**ICT 6305 Advanced Cyber Physical System 3 Credits**

Introduction to Cyber-Physical Systems, CPS Principles, Models of Physical Systems, Models of Cyber Components and Interconnections, CPS Workload Modeling, Specification and Critical Properties of CPSs, Safety in CPS, Complex Systems Approaches to CPS. Discrete systems, Continuous and Hybrid Dynamics, Fractional Order Derivatives and Integrals, Information cellular processing, Control algorithms and embedded Software, Scheduling of Control Tasks Over Shared Wireless Channels, Sensing and Fusion, Automotive Sensing and Intelligent Transportation, Wearable Sensing and Body-Area Sensor Network, Sensors and Actuators, Networked control systems, Molecular communication, Value added network, Controllability and Observability of Complex Networks. Internet of things (IoT), Internet of Service (IoS), Introduction to Industry 4.0, Big Data Issues, Hybrid systems, Real-Time Operating Systems, Holistic System Design, Controller Design and Synthesis, Multi Agent System, Real-Time Tools and Analysis, Inference Techniques, Embedded System Design, Feedback Control.

**ICT 6306 Bioinformatics Computing 3 Credits**

Introduction to Bioinformatics and Key Online Bioinformatics Resources (NCBI & EBI): Biology is an Information Science, History of Bioinformatics, Types of Data, Application Areas: Introduction to Upcoming Segments, NCBI & EBI resources for the molecular domain of Bioinformatics, Focus on Gen Bank, Uni Prot, Entrez and Gene Ontology. Sequence Alignment, DNA and Protein Database Searching: Homology, Sequence Similarity, Local and Global alignment, Database Searching with BLAST. Advanced Database Searching: PSI-BLAST, Profiles and HMMs, Protein structure comparisons. Structural Bioinformatics: Protein Structure Function Relationships, Protein Structure and Visualization Resources, Structural Genomics, Homology Modeling, Inferring Protein

Function from Structure. Structure Based Drug Discovery and BioMolecular Simulations: Small Molecule Docking Methods, Protein Motion and Conformational Variants, Bioinformatics in Drug Discovery. Genome Informatics and High Throughput Sequencing Searching: Genes and Gene functions, Genome Databases, Variation in the Genome, High Throughput Sequencing, Biological Applications, Bioinformatics Analysis Methods. Proteomics and Transcriptome: Processing and Extracting Biological Information from Proteomic and Trans-criptomic Datasets, Analysis of RNA-Seq Data, Differential Expression Tests, Avoiding PValue Misuse, Hands-on Analysis of RNA-Seq Data. Analysis of proteinProtein interactions, Pathways and Networks, Modeling and Simulation of Systems and Networks, Computational Methods of Network Modeling.

**ICT 6307 Biomedical Image Processing 3 Credits**

Fundamentals of Digital Image Processing; Image Transformation; Image Enhancement; Image Reconstruction; Image Registration; Image Segmentation; Feature Extraction. Fundamentals of Producing a Medical Image- X-Ray, MRI and CT-SCAN; Image Collection Techniques; Image Reconstruction Algorithms; Detailed Examination of the Main Areas of Medical Imaging and Clinical Application of each Area.

**ICT 6401 Intrusion Management and Ethical Hacking 3 Credits**

Introduction to Hacking Concepts, Types of Hacking, Phases of Hacking, Definition of Hacking, Necessity of Ethical Hacking, Scope and Limitations of Ethical Hacking, Information Security Controls, Information Assurance, Threat Modeling, Enterprise Information Security Architecture, Network Security Zoning, Types of Security Policies, Vulnerability Assessment, Types of Vulnerability Assessment, Network Vulnerability Assessment Methodology, Vulnerability Research Websites, Penetration Testing, Comparing Security Audit, Vulnerability Assessment, and Penetration Testing, Blue Teaming/Red Teaming, Hacking Phases, Scan for Vulnerability, Vulnerability Scanning and Tool, Network Vulnerability Scanners, Vulnerability Scanning Tools for Mobile, Network Discovery Tool, Network Topology Mapper and Network View, Network

Discovery Tools for Mobile, Gaining Access, Maintaining Access, Clearing Tracks, Information at Hand Before System
Hacking Stage, System Hacking: Goals, CEH Hacking Methodology, CEH System Hacking Steps, Cracking Passwords, Password Cracking, Types of Password Attacks, Non-Electronic Attacks, Active Online Attack, Dictionary, Brute Forcing and Rule-based Attack, Password Guessing, Default Passwords, Active Online Attack,
Trojan/Spyware/Keylogger, Active Online Attack Using USB Drive, Hash Injection Attack, Passive Online Attack, Wire Sniffing, Man-in-theMiddle and Replay Attack, Offline Attack, Rainbow Attacks, Tools to Create Rainbow Tables: rtgen and Winrtgen, Distributed Network Attack. Denial of Service: Attacks, Preventing DoS/DDoS; Buffer Overflow: Introduction, Testing Vulnerability, Countermeasures.

**ICT 6402 Applied Cryptography 3 Credits**

Introduction, Crypto History Attacks on Crypto, One-time Pad, Perfect Secrecy. Stream Ciphers, Semantic Security Block Ciphers, DES. Attacks on Block Ciphers, AES using Block Ciphers, EBC. Using block ciphers, CBC, CTR Message integrity, Collision Resistance, Authenticated Encryption, Deterministic Encryption. Basic Key Exchange, Number Theory Review, Public Key Crypto Introduction. Public Key Crypto: RSA, El Gamal. Digital Signatures. Key Management and Distribution, Digital Certificates PKI, Identity based Encryption. Identification and Authentication, Zero Knowledge Protocols, Kerberos Electronic Mail Security, PGP. Web and Transport Level Security, SSH, TLS/SSL IP Security, Wireless Network Security. Anonymous Communication, ToR Crypto-currencies, Bitcoin. Hardware–based security, Side Channel Attacks Physically Unclonable Function, Trusted Platform Module. Quantum Safe Cryptography Cloud Security.

**ICT 6403 Internet and Cyber security 3 Credits**

Internet Architecture, Working procedure of Internet, TCP/IP Vulnerabilities, Attacks, and Countermeasures, Physical Layer, Jamming

Attacks, Secured Web Programming, Data Link Layer: ARP Protocol and Cache Poisoning, Network Layer: IP Protocols, Packet Sniffering, IP Spoofing, IP Fragmentation Attacks, ICMP Protocol and ICMP Misbehaviors, IP Routing Protocol Attacks, Transport Layer: TCP Session Hijacking, Reset and SYN Flooding Attacks, DoS and DDoS Attacks, DNS Protocol and Attacks, BGP Protocol and Attacks. IP Tunneling and SSH Tunneling, Virtual Private Networks, Firewalls, Bypassing Firewalls, Transport Layer Security (TLS/SSL), TLS Programming, Secured Socket Programming, Java Script Security, Cross Site Forgery. Introduction to Cyber Security, Interrelated Components of the Computing Environment, Models of Cyber Security (the CIA triad, the Star Model), Cyber Vulnerabilities and consequences, Cyber Threats-Types of Attacker, Cyber-Attack, Methods, Classification of Cyber-Attack and Vectors, Risks of Conducting a Cyber-Attack. Cybercrime, Cyber Harassment, Cyber Warfare, Cyber Surveillance, Difficulties in Cyber Security, State of Security today. Principles of Risk, Types of Risk, Risk Strategies, Risk Management Framework, Disaster Recovery Plan and Procedures, Challenges of Disaster Recovery Plan, Traditional Disaster Recovery. National ICT Act & Policy, National Information Security Policy Guideline, Government and Private Sector Role's in Securing Cyberspace.

**ICT 6501 Computational Linguistics 3 Credits**

Introduction and Overview: Computational Linguistics, Hands-on Demonstrations, Ambiguity and Uncertainty in Language, The Turing Test; Regular Expressions: Chomsky Hierarchy, Regular Languages, and their Limitations, Finite-state Automata, Practical Regular Expressions for Finding and Counting Language Phenomena. Context Free Grammars: Constituency, CFG Definition, Use and Limitations. Chomsky Normal Form. Syntactic Processing: Grammars and Parsing, Augmented grammars, Grammars for Natural Language, Top-down Parsing, Bottomup Parsing, and the Problems with each, Ambiguity Resolution; The Desirability of Combining Evidence from both Directions. Semantic Interpretation: Semantics and Logical Form, Linking Syntax and Semantics, Scoping; Context and World Knowledge: Knowledge Representation and Reasoning,

Local Discourse Context and Reference, using World Knowledge, Conversational Agent.

**ICT 6502 Statistical Machine Translation 3 Credits** Difference between Statistical and Structured Natural Language Processing (NLP), Basic Statistics and Statistical Model, Linguistics Essentials, Corpus-based NLP; Statistical Machine Translation, Models and Techniques: Collocations, Statistical Inference, Word Sense Disambiguation, Lexical Acquisition, Markov Models; Grammar: Part-ofSpeech Tagging, Probabilistic Context Free Grammars, Probabilistic Parsing; Applications and Techniques: Statistical Alignment, Clustering, Information Retrieval, Text Categorization.

**ICT 6503 Advanced Artificial Intelligence 3 Credits**

Introduction to AI; Advanced search techniques in AI: Heuristic search, Local search, Adversarial search; Genetic and evolutionary algorithm, Knowledge-based system design: Propositional logic, First-order logic, Planning logic, Modeling constraint satisfaction and optimization problems in MiniZinc; Advanced plan generating systems: Automated classical planning, Partial-order planning (POP), SAT Planning, Hierarchical task network (HTN) planning; Bayesian network and probabilistic reasoning: Uncertain reasoning, Probabilistic reasoning, Bayesian Network, Dynamic Bayesian Network; Introduction to deep learning: Supervised, unsupervised, and reinforcement learning, Neural Network; Deep belief network, Deep neural network, deep learning for natural language processing and computer vision, and other applications; Introduction to Robotics and Robot programming.

**ICT 6504 Machine Learning 3 Credits**

Introduction; Applications; Maximum likelihood; Regularizers, basis functions and cross-validation; Supervised learning: Optimisation, Logistic regression, Perceptron, Exponential family, Generative learning algorithms, Gaussian discriminant analysis, Naive Bayes, Support vector machines, Model selection and feature selection, Ensemble methods (Bagging,

boosting), Evaluating and debugging learning algorithms; Learning theory: Bias/variance tradeoff, Union and Chernoff/Hoeffding bounds, VC dimension, Worst case (online) learning; Unsupervised learning: Clustering. K-means, EM. Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis); Reinforcement learning and control: MDPs. Bellman equations, Value iteration and policy iteration; Linear quadratic regulation (LQR), LQG, Q-learning. Value function approximation, Policy search. Reinforce. POMDPs; Back-propagation and layer-wise design of neural nets; Deep neural network; Convolutional neural networks; Recurrent neural networks and LSTMs; Deep Reinforcement learning with direct policy search; Neuro-dynamic programming.

**ICT 6505 Automated Planning 3 Credits**

Forms of planning; Domain-Independent planning; Conceptual, restricted, and extended models for planning; Representations (Set-Theoretic, Classical, and State-Variable) for planning; Complexity of classical planning; State-Space planning and the STRIPS algorithm; Plan-Space planning; Planning-Graph techniques (e.g., the Graph plan planner); Propositional satisfiability techniques; Constraint satisfaction techniques; Heuristics for state-space and plan-space planning; Control rules in planning; Hierarchical Task Network (HTN) planning; Situation Calculus and Dynamic Logic in deductive planning; Numeric Planning; Temporal planning; Planning and resource scheduling; Planning under uncertainty (based on Markov Decision processes, model checking, and Neo-Classical techniques).

**ICT 6506 Neuro-Fuzzy Systems 3 Credits**

Overview of Artificial Neural Networks; Artificial Neuron Models, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architecture, Classification of ANN; Simple neural networks; Multi-layer neural networks: Multilayer Perceptions (MLP), Logistic Activation Function, Backpropagation Algorithm; Neural Network Applications;

Overview of Fuzzy System; Crisp sets to Fuzzy Sets; Operations on Fuzzy Sets, Fuzzy Arithmetic, Fuzzy Relations.

**ICT 6601 Speech Processing 3 Credits**

Basic Concepts: Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – Acoustics of Speech Production; Review of Digital Signal Processing Concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods. Speech Analysis: Features, Feature Extraction and Pattern Comparison Techniques: Speech Distortion Measures – Mathematical and Perceptual – Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths. Speech Modeling: Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, BaumWelch Parameter Re-estimation, Implementation issues. Speech Recognition: Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary Continuous Speech Recognition System – Acoustics and Language models – Context Dependent Sub-word Units; Applications and Present Status. Speech Synthesis: Text-to-Speech Synthesis: Concatenative and Waveform Synthesis Methods, Sub-word units for TTS, Intelligibility and Naturalness – Role of Prosody, Applications and Present Status.

**ICT 6602 Antennas and Propagation 3 Credits**

Basic Antenna Parameters - Patterns, Beam Area, Radiation Intensity, Beam Efficiency, Directivity-Gain-Resolution, Antenna Apertures, Effective Height. Thin Linear Wire Antennas: Radiation from Small Electric Dipole, Quarter wave Monopole and Half wave Dipole – Current Distributions, Field Components, Radiated Power, Radiation Resistance, Beam-widths, Directivity, Effective Area and Effective Height. Antennas of Different Lengths, Illustrative Problems. Loop Antennas - Introduction, Small Loop, Comparison of Far Fields of Small Loop and Short Dipole,

Radiation Resistances and Directivities of Small and Large Loops. Helical Antennas - Helical geometry, Helix Modes, Practical Design Considerations for Monofilar Helical Antenna in Axial and Normal Modes. Horn Antennas - Types, Fermat's Principle, Optimum Horns, Design Considerations of Pyramidal Horns, Illustrative Problems.
Microstrip Antennas - Introduction, Features, Advantages and Limitations, Rectangular Patch Antennas - Geometry and Parameters, Characteristics of Microstrip Antennas. Impact of Different Parameters on Characteristics, Reflector Antennas - Introduction, Flar Sheet and Corner Reflectors, Paraboloidal Reflectors - Geometry, Pattern Characteristics, Feed Methods, Reflector Types - Related Features, Illustrative Problems. Lens Antennas - Introduction, Geometry of Non-metallic Dielectric Lenses, Zoning, Tolerances, Applications. Antenna Measurements: Introduction, Concepts - Reciprocity, Near and Far Fields, Coordinate System, Sources of Errors. Patterns to be Measured, Pattern Measurement Arrangement, Directivity Measurement, Gain Measurements (by Comparison, Absolute and 3-Antenna Methods). Introduction,
Definitions, Categorizations and General Classifications, Different Modes of Wave Propagation, Ray/Mode Concepts, Ground Wave Propagation (Quantitative Treatment) - Introduction, Plane Earth Reflections, Space and Surface Waves, Wave Tilt, Curved Earth Reflections, Space Wave Propagation - Introduction, Field Strength Variation with Distance and
Height, Effect of Earth's Curvature, Absorption, Super retraction, MCurves and Duct Propagation, Scattering Phenomena, Tropospheric Propagation. Sky Wave Propagation - Introduction, Structure of Ionosphere, Refraction and Reflection of Sky Waves by Ionosphere, Ray Path, Critical Frequency, MUF, LUF, OF, Virtual Height and Skip
Distance, Relation between MUF and skip Distance, Multi-hop Propagation.

**ICT 6603 Radar Engineering 3 Credits**

Introduction to Radar: Historical background, radar terminology, radar band designations, Radar block diagram, radar equation: detection of signals in noise and signal-to-noise ratio, Probabilities of detection & False alarm, integration of radar pulses, radar cross section, distributed targets,

Transmitted power, pulse-repetition frequency, antenna parameters & system losses, introduction to radar clutter. Radar Types: Pulse radars and CW radars, Advantages of coherent radar, Doppler radar and MTI: Doppler effect, delay-line cancellers, blind speeds, staggered PRFs, Digital filter bank, Moving Target Detector, limitations of MTI, tracking with radar, monopulse tracking, conical scan, limitation to tracking accuracy. Radar Signals & Clutter: Basic radar measurement, theoretical accuracy of radar measurements, Range and velocity ambiguities, the ambiguity diagram, pulse compression-principles, the matched filter, chirp waveforms, Waveform design: nonlinear FM, phase codes, waveform generation and compression Descriptions of land & sea clutter, statistical models for surface clutter, detection of targets in clutter. Module –IV: Devices and Radar Systems: 8L Radar transmitter: Solidstate RF power source, Magnetron, other RF power sources, Radar receiver: Super heterodyne receiver, receiver noise figure, duplexers & diplexers, Receiver protectors, Applications: Electronic Warfare: ESM, ECM, ECCM; super resolution, IFM, types of jammers, Stealth and counter-stealth: stealth techniques for aircraft and other target types, low frequency and UWB radar.

**ICT 6604 Advanced Digital Signal Processing 3 Credits**

Discrete Random Signal Processing: Discrete Random Processes-Ensemble averages, stationary processes, Autocorrelation and Auto covariance matrices. Parseval's Theorem, Sum Decomposition Theorem. Wiener-Khintchine Relation- Power Spectral Density- Periodogram Spectral Factorization, Filtering random processes. Low Pass Filtering of White Noise. Parameter estimation: Bias and consistency. Spectrum Estimation: Estimation of spectra from finite duration signals, NonParametric Methods-Correlation Method, Periodogram Estimator, Performance Analysis of Estimators- Unbiased, Consistent Estimators-Modified Periodogram, Bartlett and Welch methods, Blackman & Tukey Method. Parametric Methods - AR, MA, and ARMA model based spectral estimation. Parameter Estimation -Yule-Walker equations, Solutions using Durbin’s algorithm. Linear Estimation and Prediction: Linear prediction-Forward and Backward Predictions, Solutions of the Normal EquationsLevinson-Durbin Algorithms. Least mean squared error criterion

-Wiener filter for filtering and prediction, FIR Wiener filter and Wiener IIR filters, Discrete Kalman filter. Adaptive Filters and Multirate DSP: FIR adaptive filters -adaptive filter based on steepest descent method- Widrow-H off LMS adaptive algorithm, Normalized LMS. Adaptive channel equalization-Adaptive echo cancellation-Adaptive noise cancellation-Adaptive recursive filters (IIR). RLS adaptive filters-Exponentially weighted RLS-sliding window RLS. Polyphase filter structures, timevariant structures. Multistage implementation of multirate system. Application to sub bandcoding - Wavelet transform and filter bank implementation of wavelet expansion of signals. Digital Signal Processors and its Applications: General purpose Digital Signal Processors.

**ICT 6605 Advanced VLSI Design and Testing 3 Credits**

Overview of VLSI technology; Review of CMOS logic circuits; Scaling and Interconnect Issues; Deep submicron design issues; Advanced clocking strategies; Clock distribution trees; High speed switching circuits; Low power design; Memory circuit design trends, Performance optimization; SOI technology and circuits; VLSI circuit in signal processing, VLSI circuit in wireless communication; Introduction to ASIC design. Overview of VLSI circuit; Faults in VLSI circuit; Fault modeling; Fault simulation: Serial, parallel and deductive fault simulation; Testing stuck faults and bridging faults; Test algorithms; Automatic test equipment, Functional testing; Design For Testability: controllability and observability, scan techniques, Built in self-Test; Compression techniques; Testing of digital core; Memory Testing; Testing of analog and mixed signal core; Iddq Testing, Production Testing; Test effectiveness: coverage, yield and defect levels; System level test and diagnosis; MCM and core based testing.

**ICT 6606 Reliable Computing System 3 Credits**

Fault classification and measures of fault tolerance. Hardware fault tolerance: basic terminology and structure of hardware fault tolerance.
Information redundancies for detection and correction of faults. Software fault tolerance and check pointing. Defect tolerance in VLSI circuits. Simulation techniques of fault tolerance. Fault injection techniques. Case

studies of modern fault tolerant processors. Multi-core processing and fault tolerance back-up. Error and Exception Handling.

**ICT 6701 Wireless Networks 3 Credits**

Overview of Wireless Communication Networking and Mobile Computing: Historical perspectives, first and second generation cellular systems, land mobile vs. satellite vs. indoor wireless systems, adaptation and mobility in wireless information systems, challenges of mobile computing, mathematical preliminaries. Wireless Channel Modeling: Path-loss and shadow fading models, Rayleigh and Ricean fading, coherence time, coherence bandwidth, frequency flat and selective fading. Modulation, Coding, Diversity Techniques: Digital modulation and coding techniques for wireless communication systems, spread-spectrum modulation, diversity combining techniques. Cellular Concept: Frequency reuse/cellular/microcellular concepts including sectorization and cell splitting, trunking efficiency, Erlang capacity. Multiple Access Techniques: TDMA, FDMA, CDMA, ALOHA, Slotted-ALOHA, CSMA/CA, MACA, reservation protocols, PRMA, capture effects. Wireless Networking Standards: 3G Systems, Wireless LAN standards (IEEE 802.11), WMAN standards (IEEE 802.16), WPAN standards (IEEE 802.15).

**ICT 6702 Advanced Communication Engineering 3 Credits**

Communication Engineering Preliminaries, traffic sources, resources, operational modes and traffic, unit of traffic, inter-arrival time and call holding time, traffic variation and busy hours; Random variables: Random variables, probability distribution function, probability density function, moments, Bernoulli random variable, uniform discrete random variable, Binomial distribution, Poisson distribution, negative exponential distribution, quality of service circuit switching voice networks, packet switched networks, probabilities of traffic systems; Models for circuit switched networks: Kendall notation, Erlang's loss formula (M/M/n/n) and examples, marginal utility, Wilkinson's model, equivalent random method and examples, overflow routing in circuit switched networks; Models for packet switched networks: M/M/1, M/G/1, M/G/1 priority queues, Erlang's

delay formula (M/M/n), System simulation: random number and random variable generation, event-by-event simulation method, sampling theory.

**ICT 6703 Radio Frequency Technology 3 Credits**

Networks And Matrices: Scattering and chain scattering matrices, Generalized scattering matrix, Analysis of two port networks, Interconnection of networks. Positive real concepts, scattering matrix, representation of microwave components (directional coupler, circulators, hybrids and isolators). High Frequency Circuit Design: Tuned Circuits, Filter design- Butterworth filter, Chebyshev filter, impedance matching. High frequency amplifier, BJT and FET amplifier, Broadband Amplifiers RF Oscillators, Colpitts, Hartley Oscillators, PLL. High Frequency Integrated Circuits. Microwave Amplifier Design: Types of amplifiers, Power gain equations. Introduction to narrow band amplifiers basic concepts, Maximum gain design, Low noise design. High power design, Negative resistance, reflection amplifiers – various kinds – stability considerations, Microwave transistor amplifier design – input and output matching networks – constant noise figure circuits. Microwave Transistor Oscillator Design: One port and two port negative resistance oscillators. Oscillator configurations, Oscillator design using large signal measurements, Introduction to Microwave CAD packages, Microwave integrated circuits, MIC design for lumped elements. RF And Microwave Antennas: Radiation from surface current and line current distribution, Basic Antenna parameters, Feeding structure-Patch Antenna, Ring Antenna, Micro strip dipole, Micro strip arrays, Traveling wave Antenna, Antenna System for Mobile Radio-Antenna Measurements and Instrumentation. Propagation characteristics of RF and Microwave signals, Introduction to EBG structures.

**ICT 6704 Advanced Telecommunication Network 3 Credits**

Role of Telecommunications in Developing Countries, Telecom Organizations and Standardization: Administrative Organizations: ITU, National PTTs, Private Telephone Companies; Standardization Bodies:

ITU-T, ITU-R, etc. Public Switched Telephone Network : Network Topology: International, National and Local Networks, Architecture of the Analog PSTN; Switching Hierarchy; Trunk Networks; Junction Networks; Local Distribution Networks; Local Loop and 2W/4W Circuits; Architecture of the Digital PSTN; DSL; Signaling; Dialing; Tone Dialing; DTMF; Telephone Terminals Common Channel Signaling; Telephone Numbering in PSTN; Signals Carried Over the Network: Types of Information and Their Requirements; Simplex, Half-Duplex, and FullDuplex Communications; Frequency and Bandwidth; Analog and Digital Signals and Systems; Frequency Division Multiplexing ; Time Division Multiplexing ; Pulse Code Modulation; Speech Coding; Power Levels of Signals; Decibel; Gain and Loss. Transmission Media and Systems: Transmission Media: Copper Pairs; Optical Fibers; Radio Waves; Overview on Transmission Systems; Microwave Radio Relay Lines; Satellite Communications Networks; Optical Fiber Communication Networks; Mobile Communication Systems; Wireless Local Loop Systems.

**ICT 6705 Next Generation Mobile Communication 3 Credits**

Introduction to Personal Communications Services (PCS): PCS Architecture, Mobility management, Networks signaling. Global System for Mobile Communication (GSM) system overview: GSM Architecture, Mobility management, Network signaling, Performance Analysis: Admission control and handoffs. 2.5/3G Mobile Wireless systems: packet switched Data Introduction, 3G CDMA cellular standards, Wideband Code Division Multiple Access (W-CDMA), and CDMA 2000, Quality of services in 3G. 2.5/3G TDMA: General Packet Radio Services (GRPS) and EDGE. Access Scheduling techniques in cellular systems: Slotted Aloha access, integrated access: voice and data, scheduling in packet based cellular systems. Mobile Data Communication: WLANs (Wireless LANs) IEEE 802.11 standard, Mobile IP. Wireless Application Protocol (WAP): The Mobile Internet standard, WAP Gateway and Protocols, wireless mark up Languages (WML).Wireless Local Loop (WLL): Introduction to WLL Architecture, wireless Local Loop Technologies. Global Mobile Satellite Systems; case studies of the IRIDIUM and GLOBALSTAR systems.

**ICT 6706 Broadband and Wireless Communications 3 Credits**
Overview of broadband wireless communications, WiMAX Genesis and framework 9 802.16 standard, WiMAX forum, Other 802.16 standards, Protocol layer topologies - Layers of WiMAX, CS, MAC CPS, Security layer, Physical layer, Reference model, topology. Unit No. II: Frequency utilization and system profiles 9 Cellular concept, Licensed and unlicensed frequencies, Fixed WiMAX system profiles, Mobile WiMAX profiles. Unit No. III: WiMAX physical layer 9 OFDM Transmissions, SOFDMA, subcarrier permutation, 802.16 transmission chains, Channel coding, Turbo coding, Burst profile. Unit No. IV: WiMAX MAC and QoS 9 CS layer, MAC function and frames, Multiple access and burst profile, Uplink bandwidth allocation and request mechanisms, Network entry and QoS management. Unit No. V: Radio engineering considerations 9 Radio resource management, Advance antenna technology in WiMAX, MBS.
WiMAX architecture, Mobility handover and power save modes, Security.

**ICT 6707 Smart Sensor Networking 3 Credits**

Introduction to sensor technology, Sensor systems; Smart sensors basics; Smart sensors: Characteristics; Smart sensors architectures; Smart sensors buses and interfaces; Smart sensors software; Data acquisition methods for smart sensors; Virtual sensor systems; Smart sensors for electrical and non-electrical variables; Sensor networks architectures: Single node architecture; Multi node architectures; Design principles; Energy efficient topologies; Wired sensor networks and wireless sensor networks; Applications; Communication protocols: Physical layer; MAC protocols; Link layer protocols; Localization and positioning; Routing protocols; Transport layer; Data gathering and processing: Protocols for gather information; Data processing techniques; Energy management: Energy consumption of sensor nodes; energy harvesting; Techniques for reducing consumption and communication energy; Energy aware routing; Security, reliability and fault-tolerance: Security and privacy protection; Reliability support; Fault-tolerance; Sensor networks standards; platforms and tools: IEEE 802.15.4, IEEE 802.15.6 and IEEE 802.11; Berkeley motes; Sensor Operating Systems.

**ICT 6708 Advanced Computer Network 3 Credits** Design and implementation of computer communication networks and their end-to-end protocols. layered network architectures, applications, transport and routing, routing protocols, IP version 6, mobile IP, multicasting, session initiation protocol, quality of service, network security, network management, and TCP/IP in wireless networks. Data center architectures; Data center network protocols, Data center workloads and performance, Data center network virtualization End host architectures; Server and network virtualization, Software defined networking, Wireless sensor networks; IoT networks, Network verification, Machine learning for networks. Networks Layer: Packetizing, Routing and Forwarding, Packet Switching, Network Layer Performance, IPv4 Address, Address Space, Classful Addressing, Classless Addressing, Dynamic Host Configuration Protocol (DHCP), Network Address Translation (NAT), Forwarding of IP Packets, Forwarding based on Destination Address, Forwarding based on Label, Routing as Packet Switches. Unicast Routing : Introduction, Routing Algorithms-Distance Vector Routing, Link State Routing, Path Vector Routing, Unicast Routing Protocols- Routing Information Protocol (RIP), Open Short Path First Version.

**ICT 6709 Advanced Data Communications 3 Credits**

Data Communications, Networks and Network Types, Internet History, Standards and Administration, Protocol Layering, TCP/IP protocol suite, OSI Model. Digital Data Transmission, DTE-DCE interface. Data Link Layer: Introduction, Data Link Layer, Nodes and Links, Services, Categories of Links, sub layers, Link Layer Addressing, Address Resolution Protocol. Error Detection and Correction: Types of Errors, Redundancy, detection versus correction, Coding Block Coding: Error Detection, Vertical redundancy cheeks, longitudinal redundancy cheeks, Error Correction, Error correction single bit, Hamming code. Cyclic Codes: Cyclic Redundancy Check, Polynomials, Cyclic Code Encoder Using Polynomials, Cyclic Code Analysis, Advantage of Cyclic Codes, Checksum Data Link Control: DLC Services, Data Link Layer Protocols,

HDLC, Point to Point Protocol. Switching: Introduction to Switching, Circuit Switched Networks, Packet Switching, Structure of switch Multiplexing: Multiplexing, Frequency Division Multiplexing,
Time Division Multiplexing. Connecting devices: Passive Hubs, Repeaters, Active Hubs, Bridges, Two Layer Switches, Routers, Three Layer Switches, Gateway, Backbone Networks. Wired LANS: Ethernet Protocol, Standard Ethernet, Fast Ethernet, Gigabit Ethernet, 10 Giga bit Ethernet. Media Access Control (MAC) Sub Layer Random Access, ALOHA, Carrier Sense Multiple Access (CSMA), Carrier Sense Multiple Access with Collision Detection (CSMA/CD), Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), Controlled Access- Reservation, Polling- Token Passing, Channelization – Frequency Division Multiple Access (FDMA), Time – Division Multiple Access (TDMA), Code Division Multiple Access (CDMA). Spectrum Spreading: Spread Spectrum-Frequency Hopping Spread Spectrum and Direct Sequence Spread Spectrum.

**ICT 6710 Satellite and Navigation 3 Credits**

Orbits & Launching Methods: Kepler laws, Orbital elements, Orbital perturbations, Apogee perigee heights, Inclines orbits, Sun synchronous orbits, Geo stationary orbits, Limits of visibility, Sun transit outage, polar Mount antenna, Antenna Look angles, launching orbits, Low earth orbits, medium orbits, constellation. Space Link: EIRP, transmission losses, power budget equation, system Noise carrier to Noise ration, Uplink and downlink equations, Input and Output back Off, TWTA, Inter modulation Noise, C/No, G/T measurement. Space & Earth Segment: Space segment, space subsystems payload, Bus, power supply, attitude control, station keeping, thermal control, TT & C Subsystem, Transponders, Antenna subsystem, Earth segment, cassegrain antenna, Noise temperature, Low Noise Amplifiers, Earth station subsystems, TVRO. Single channel per carrier. MCPC, Combanded FDM/FM/FDMA, Time division multiplexing, T1 carrier, Time Division multiple Access, Frame Burst structure, Frame efficiency, frame Acquisition and synchronization, SS TDMA, SPADE, Spread spectrum, direct sequence, CDMA. Satellite Services: INTELSAT, INSAT Series, VSAT, Weather forecasting, Remote sensing, LANDSAT, Satellite Navigation, Mobile satellite Service, Direct to Home.

**Bangabandhu Satellite-1**: Evaluation History, Spacecraft Properties, Orbital Position, Transponders, Platform.

**ICT 6711 Geographical Information System 3 Credits**

Remote Sensing (RS) Technologies: Basic Technology Requirement, Aerial Photography, Satellite Image, Microwave Remote Sensing, Electro-optical Remote Sensing, Wireless Sensor Network Based Remote Sensing. Introduction to Geographical Information Systems (GIS) and Remote Sensing (RS) Concepts; Basic Principles and Techniques used in GIS and RS; Practice Applications and their Evolutions using GIS and RS; Global Positioning System (GPS). Fundamentals of GIS, Basic Hardware, Software and Data Requirements for GIS; Evolution of GIS Technology, Key Areas of Application of GIS; Spatial Data and Modeling & Analysis, Issues in the Management of GIS, Organizational Role of GIS, and Emerging trends in GIS Development and Future Usage.

**ICT 6801 Advanced Embedded System Design 3 Credits**

Typical embedded system: Core of the embedded system, Memory, Sensors and Actuators, Commutation interface, Embedded firmware, Other system components. Characteristics and quality attribution of Embedded Systems. Hardware software co-design and program modeling: Fundamental issues in hardware software co-design, Computational models in embedded design, Introduction to Unified modelling language, Hardware software trade-off. Embedded firmware design and development: Embedded firmware design approaches, Embedded firmware development language. Realtime operating system (RTOS) based embedded system design: Operating system basics, Types of OS, Tasks, Process and threads, Multiprocessing and multitasking, Task scheduling, Threads, Processing and scheduling: Putting them altogether, Task communication, task synchronization, Device drivers, How to choose an RTOS. The embedded system development environment: The Integrated development environment (IDE), Types of files generated on cross compilation, Disassembler / Decompilers, Emulators and debugging, Target hardware debugging, Boundary scan. Trends in the embedded industry: Processor

trends in embedded system, Embedded OS trends, development language trends, Open standards, Frameworks and alliances, Bottlenecks.

**ICT 6802 Real Time Computing for Embedded System 3 Credits**

Definition of real-time, temporal and event determinism, design principles and practice; Architecture review and interfacing, interrupts, traps and events, response times and latency, real-time clocks; Operating systems: Structure of an RTOS, nucleus, servers, schedulers and dispatchers; Synchronization and communication: priority and distribution queues, system Modeling, static scheduling, priority drive scheduling; Real-time communication, device drivers, operating systems; Languages in realtime, concurrency issues, Real-time programming.

**ICT 6803 Industrial Automation and Control 3 Credits**

Industrial Automation and Control, Architecture of Industrial Automation Systems, Sensors and measurement systems, Temperature measurement, Pressure and Force measurements, Displacement and speed measurement, Flow measurement techniques, Measurement of level, humidity, pH etc, Signal Conditioning and Processing, Estimation of errors and Calibration, Introduction to Process Control, PID Control, Controller Tuning, Implementation of PID Controllers, Special Control Structures: Feedforward and Ratio Control, Special Control Structures : Predictive Control, Control of Systems with Inverse Response, Special Control Structures: Cascade Control, Overriding Control, Selective Control, Split Range Control, Sequence Control, PLCs and Relay Ladder Logic,
Sequence Control: Scan Cycle, RLL Syntax, Sequence Control: Structured Design Approach, Sequence Control: Advanced RLL Programming, Sequence Control: Hardware Environment, Control of Machine tools: CNC Machines, Control of Machine Tools: Analysis of a control loop, Actuators: Flow Control Valves, Hydraulic Actuator Systems: Components and Symbols, Hydraulic Actuator Systems: Pumps and Motors, Proportional and Servo Valves, Pneumatic Control Systems: System Components, Controllers and Integrated Control Systems, Electric Drives: Energy Saving with Adjustable Speed Drives, Step motors: Principles, Construction and

Drives, DC Motor Drives: DC-DC Converters, Adjustable Speed Drives, Induction Motor Drives: Characteristics, Adjustable Speed Drives, Synchronous Motor Drives: Motor Principles, Adjustable Speed and Servo Drives, Networking of Sensors, Actuators and Controllers: The Field bus, The Field bus Communication Protocol, Introduction to Production Control Systems.

**ICT 6804 Advanced Computer Architecture 3 Credits** Course Introduction, Introduction to Computer Architecture, Instruction set architecture, Evolution of architectures, RISC architecture (Single cycle, multi-cycle, and pipelined architectures), Pipeline hazards, Memory system, Cache architecture, Beyond Pipeline, Superscalar architecture, Superscalar architecture: An overview, Instruction flow optimization: Handling branches, Branch predictors – 1, Branch predictors – 2, Advanced optimization in instruction flow, register flow techniques: Register renaming and out of order execution, Out of order execution,
Advanced data flow techniques: Instruction reuse and value prediction, Memory data flow, Advanced memory data flow architectures, Limits of superscalar architectures, Beyond ILP, Multi-threading, Simultaneous multithreaded (SMT) architectures, SMT architecture: Choices, SMT performance on various designs, SMT architecture: OS impact and adaptive architectures, VLIW architectures, Multi-scalar architecture, Multi-core Architectures, Multi-core Interconnect – NOC, Network-onChip, Cache Coherence, Cache Consistency model, Dynamic Core architectures, GP-GPU Architecture, CPU-GPU Integration.

**ICT 6805 Advancement in Microprocessor Systems 3 Credits** Introduction: Need of advance microprocessors, Difference between RISC and CISC, RISC Design philosophy, ARM Design Philosophy, History of ARM microprocessor, ARM processor family, Development of ARM architecture. The ARM Architecture and Programmers Model : The Acorn RISC Machine, ARM Core data flow model, Architectural inheritance, The ARM7TDMI programmer's model: General purpose registers, CPSR, SPSR, ARM memory map, data format, load and store architecture, Core extensions, Architecture revisions, ARM development tools. ARM

Instruction set: Data processing instructions, Arithmetic and logical instructions, Rotate and barrel shifter, Branch instructions, Load and store instructions, Software interrupt instructions, Program status register instructions, Conditional execution, Multiple register load and store instructions, Stack instructions, Thumb instruction set, advantage of thumb instructions, Assembler rules and directives, Assembly language programs for shifting of data, factorial calculation, swapping register contents, moving values between integer and floating point registers. Programming for ARM: Overview of C compiler and optimization, Basic C data types, C Looping structures, Register allocations, function calls, pointer aliasing, structure arrangement, bitfields, unaligned data and Endianness, Division, floating point, Inline functions and inline assembly, Portability issues. C programs for General purpose I/O, general purpose timer, PWM Modulator, UART, I2C Interface, SPI Interface, ADC, DAC.Memory management units: Moving from memory protection unit
(MPU) to memory management unit (MMU), Working of virtual memory, Multitasking, Memory organization in virtual memory system, Page tables, Translation look aside buffer, Caches and write buffer, Fast context switch extension. Advanced Topics: Advanced Microprocessor Bus Architecture (AMBA) Bus System, User peripherals, Exception handling in ARM, ARM optimization techniques.

**ICT 6900 Selected Topics in ICT 3 Credits**