Khulna University of Engineering & Technology (KUET)
Institute of Information and Communication Technology (IICT)

Course Structure and Outline for
Postgraduate Studies in Information and Communication Technology

Summary of the Courses:

A. Compulsory Courses:

Course No.	Course Title	Credit
ICT 6000	Thesis for Ph.D.	45
ICT 6800	Thesis for M.Sc. Eng.	18
ICT 6900	Project for M.Sc. Eng.	9

B. Elective Courses:

Sl. No.	Course No.	Course Title	Credit
1.	ICT 6101	Advanced Computer Architecture	3
2.	ICT 6102	Advanced Database Systems	3
3.	ICT 6103	Advanced Software Engineering	3
4.	ICT 6104	Distributed Systems	3
5.	ICT 6105	Real Time Operating Systems	3
6.	ICT 6106	Data Warehousing and Mining	3
7.	ICT 6201	Web Engineering	3
8.	ICT 6202	Advanced Computer Networking	3
9.	ICT 6203	Network Management and Security	3
10.	ICT 6204	Advanced Network Security	3
11.	ICT 6205	Computer Security	3
12.	ICT 6206	Applied Cryptography	3
13.	ICT 6207	e-Commerce Systems and Security	3
14.	ICT 6208	E-Governance	3
15.	ICT 6301	Advanced Digital Communication	3
16.	ICT 6302	Advanced Optical Communication	3
17.	ICT 6303	Mobile and Wireless Communication	3
18.	ICT 6304	Advanced Wireless Communication	3
19.	ICT 6305	Telecommunication Networks	3
20.	ICT 6306	Tele-traffic Engineering	3
21.	ICT 6307	Wireless Sensor Network	3
22.	ICT 6308	Spread Spectrum Communication	3
23.	ICT 6401	Advanced Digital Image Processing	3
24.	ICT 6402	Advanced Digital Signal Processing	3
25.	ICT 6403	Advanced VLSI Design	3
26.	ICT 6404	Real Time Computing for Embedded System	3
27.	ICT 6405	Advanced Embedded System Design	3
28.	ICT 6406	Soft Error Tolerance	3
29.	ICT 6501	Speech Processing	3
30.	ICT 6502	Speech Recognition	3
31.	ICT 6503	Machine Translation	3
32.	ICT 6504	Computational Linguistics	3
33.	ICT 6505	Computer Graphics and Animations	3
34.	ICT 6506	Computer Vision	3
35.	ICT 6507	Multimedia Technologies and Applications	3
36.	ICT 6508	Computer Applications in Medicine and Diagnosis	3
37.	ICT 6509	Medical Imaging Systems	3
38.	ICT 6510	Bioinformatics	3
39.	ICT 6601	Soft Computing	3
40.	ICT 6602	Bio-inspired Computing Techniques	3
41.	ICT 6700	Special Study in Information and Communication Technology	3

Outline of the Courses:

ICT 6000: Thesis for Ph.D. / ICT 6800: Thesis for M.Sc. Eng. / ICT 6900: Project for M.Sc. Eng.

A student must complete a Thesis/Project study under the guidance of a supervisor.

ICT 6101: Advanced Computer Architecture *(Theory: 3 Hours/Week, Credit: 3.0)*

Measurement of Performance & Cost: Performance measurement of Benchmarks, Costs of Building computers. **Instruction Sets**: Classifying instruction sets, Interactions between languages and instruction sets, measuring instruction set usage, Instruction set examples. **Improving CPU Performance**: Pipelining, Basic pipelining, Data & control hazards, Dynamic instruction scheduling, Branch prediction, Instruction-level parallelism, VLIW processor. **Vector Processors**: Vector architecture & design, Vector performance. **Memory Hierarchies**: Evaluating memory hierarchy performance, Cache design & optimization, Virtual memory design, Memory protection, Memory coherency. **Storage Systems**: Types and uses of storage devices, Interfacing I/O to the rest of the system, Reliability and availability, I/O system design. **Multiprocessors:** Classifying parallel architectures, Centralized vs. distributed shared memory, Interconnection topologies, Synchronization, Memory consistency.

ICT 6102: Advanced Database Systems *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction: Distributed Data Processing, Distributed Databases System, promises of DDBS, Problem areas. **Overview of Relational DBMS**: Relational Databases Concepts, Normalization, Integrity rules, relational data languages. **Distributed DBMS Architecture:** Architectural Models for Distributed DBMS, DDMBS Architecture. **Distributed Database Design**: Alternative Design Strategies, Distribution Design issues, Fragmentation, Allocation. **Query Processing and Decomposition:** Query processing Objectives, Characterization of query processors, layers of query of query processing, query decomposition, Localization of distributed data. **Distributed query Optimization:** Query optimization, centralized query optimization, Distributed query optimization algorithms. **Transaction Management**: Definition, properties of transaction, types of transactions, Distributed concurrency control. Serialization, Concurrency Control Mechanism &Algorithms, Time stamped and Optimistic concurrency control Algorithms, Dead lock Management. **Distributed DBMS Reliability:** Reliability concepts and Measures, fault-tolerance in Distributed systems, failures in Distributed DBMS, local & Distributed Reliability Protocols, site failures and Network partitioning. **Parallel Database Systems**: Database Series, Parallel Architecture, Parallel DBMS Techniques, Parallel exception problems, Parallel Execution for Hierarchical architecture. **Distributed object Database Management Systems**: Fundamental object concepts and Models, Object Distributed Design, Architectural Issues, Object Management, Distributed Object storage, Object query Processing. **Object Oriented Data Model**: Inheritance, object identity, persistent programming languages, persistence of objects, comparing ODDBMS and ORDBMS.

ICT 6103: Advanced Software Engineering *(Theory: 3 Hours/Week, Credit: 3.0)*

Object-Oriented Modeling and Design: Advanced object modeling, Dynamic modeling, Functional modeling. **System design**: overview of system design, allocating subsystems to processors and tasks, management of data stores, choose software control implementation, handling boundary conditions, etc. **Object design**: overview of object design, designing algorithms, design optimization, object representation, documenting design decisions, etc. **Software Projects Type**: Software projects classification, according to application field, according to architectures, according to objectives, according to development conditions. **Configurable products classification**: MIS, ERP, CRM, SCM, PRM, DSS, EIS, OA, EAI, CTI, SCADA. **Software Production Process Techniques:** Techniques to collect and represent the end user needs, Scenarios, BPM, Workflow, Extended examples of XML family languages use to define requirements. **Techniques for the definition of the contents of the solution**: Domain Analysis, Gap Analysis, Contents representation methods, Test plans. **Techniques for the solution architecture definition**: Design Patterns, Visual Inheritance, Delegation, Real time system architectures. **Techniques for the solution realisation**: RAD Environments and product configuration toolkits test driven development, Refactoring, Techniques for solution deployment and distribution, User training techniques, Techniques for solution management, maintenance and inventory, Outline of IEEE Standards. **Software Process management Techniques**: Project set up, technological resources selection, human resources selection, the project plan, the choice of process management tools, WBS. Techniques for change management, Techniques for controlling project progress.

ICT 6104: Distributed Systems *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction to communication model: Socket, Remote Procedure Call, Remote object invocation, message oriented communication, Naming service, Clock synchronization. **Distributed object based system**: CORBA distributed COM, Distributed file system, replication, distributed transactions, Security management, and recovery.

ICT 6105: Real Time Operating Systems *(Theory: 3 Hours/Week, Credit: 3.0)*

Review of operating systems: Basic principles, system calls, files, processes, design and implementation of processes, communication between processes, operating system structures. **Distributed operating systems:** Topology, network types, communication, RPC, client-server model, distributed files systems, design strategies. **Real-time models and languages**: Event-based, process-based, and graph-based models, Petri net models, real-time languages, RTOS tasks, real-time scheduling, interrupt processing, synchronization control blocks, and memory requirements. **Real-time kernel**: Principles, design issues, polled loop systems, RTOS porting to a target, comparison and study of various RTOSs like QNX, VxWorks, PSOS, and C executive, case studies. **RTOS**

ICT 6304: Advanced Wireless Communication *(Theory: 3 Hours/Week, Credit: 3.0)*

Overview of advanced wireless technologies; Standardization trends in wireless communication; Evolution of wireless technologies; Understanding of LTE and LTE-Advanced communications. Network technologies for IMT-Advanced and LTE-Advanced communications. QoS requirements and key challenging issues for 3G and 4G communications; Application of cognitive radio in4G communication; Service provisioning for 3G, 4G, and 5G communications. Overview of Mobile WiMAX network. Network architecture and QoS provisioning for Mobile WiMAX network; Basic concept of femtocelluar network; Network architecture and QoS provisioning for femtocelluar network; Basic concept of Visible Light Communication (VLC).Network architecture and QoS provisioning for VLC; Introduction to N-screen technology.

ICT 6305: Telecommunication Networks *(Theory: 3 Hours/Week, Credit: 3.0)*

Overview of telecommunication: history, evolution, convergence of telecommunication and data networks, standards. **Basics of communication systems**: modulation, multiplexing, Switching system, circuit switching, packet switching, Voice over Internet Protocol (VoIP), Fax over IP network, voice over frame relay, and ATM. **Telephony**: operating principles, telephone apparatus, description of the modern phone. **Telephone switching systems**: PBX, Centrex, ACDs, call centers, computer integration. **Data communication equipment**: introduction to terminals, modems, RS-232 and other interfaces, modem types, Tele-Traffic analysis. **Cellular telephony**: Frequency reuse, frequency management, channel alignment, handoffs strategies, FDMA, TDMA, CDMA and GSM, Introduction to satellite communication, Optical fiber communication, Submarine cables, Digital Radio Microwave, etc.

ICT 6306: Tele-traffic Engineering *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction: 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, simulation program organization, use of GSPN and other simulation tools.

ICT 6307: Wireless Sensor Network *(Theory: 3 Hours/Week, Credit: 3.0)*

Sensor mote and its architecture, Different Sensor motes, Wireless Sensor Network Architecture, Different protocol layers of Wireless Sensor Networks, Constrains of Wireless Sensor Networks. Time Synchronization; TDMA, CDMA, CSMA, CSMA-CA, Contention-based Protocols, Schedule-based Protocol, LR-WPAN (IEEE-80~.15.4a), AODV"DSDV, DSR etc., Node deployment and Sensing Coverage; Localization., Multi-channel Assignment, Mobility and Security in Sensor Network, Interworking with other Networks, Introduction to other Short Range Technologies (Bluetooth, WLAN,RFID), Interferences, Applications of Wireless Sensor Networks.

ICT 6308: Spread Spectrum Communication *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction to spread spectrum communication systems, CDMA evolution, basics of digital communication, CDMA coding, forward error control coding in spread spectrum systems, link structure of CDMA, CDMA communication on fading channels, call processing and handoff, power control, CDMA RF hardware, repeater, and cellular networks, analysis of wireless link, common air interface (CAI) parameters, PN offset planning, W-CDMA.

ICT 6401: Advanced Digital Image Processing *(Theory: 3 Hours/Week, Credit: 3.0)*

Digital Image Fundamentals, Image Enhancement and Restoration, Color fundamentals, pseudo-color and full-color image processing, color transformations, smoothing and sharpening, segmentation and matching, noise reduction. Image Compression, various coding for image compression, video compression techniques, Pattern recognition techniques, image segmentation, detection, thresholding, clustering, decision function, pattern classification, training techniques, applications of AI techniques, character recognition, automated visual inspection, stereo imaging, JPEG, MPEG, etc.

ICT 6402: Advanced Digital Signal Processing *(Theory: 3 Hours/Week, Credit: 3.0)*

Main features and applications of digital signal processing, Introduction to speech, image and data processing. **Discrete-time signals, sequences:** linear systems, linear constant coefficient difference equations. **Sampling of continuous time signals**: Two dimensional sequences and systems, Z-transform, Inverse Z-transform theorems and properties, System function, two dimensional Z-transform, H-transform. **Frequency domain representation of discrete time systems and signals**: Discrete Fourier series and Fourier transform, properties of discrete Fourier transform (DFT), parseval's theorem, equivalent noise definition of bandwidth, Convolution, correlation and method of numerical integration, Computation of the DFT, Goertzel, FFT and Chirp Z- transform algorithms. **Introduction of digital filters**: IIR and FIR digital filters, digital filter ensign technique, Adaptation algorithms, all-zero, pole-zero and lattice iaptice filters, Applications of adaptive filtering, Introduction to arametric and model –based signal processing. Introduction, discrete time stems, z- transforms, Flow graphs and matrix representation of

digital work. Wave digital filters, Discrete Fourier transform, Fast Fourier transform, Digital filter Addison, Hardware implementation of digital filters.

ICT 6403: Advanced VLSI Design *(Theory: 3 Hours/Week, Credit: 3.0)*

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. **CMOS and BiCMOS Design Process**: Stick diagram and Lambda-based design rules, Subsystem Design processes. **Subsystem Design Layout**: Gate Logic, Combinational Design, Clocked Sequential circuits, Bus designs. **Design of Computational Elements**: ALU sub-system, Adder, Multipliers, Memory, Registers, and aspects of system timing. **Architectural Synthesis**: Circuit specification, Architectural optimization, Data-path synthesis, Control unit synthesis and synthesis of pipelined circuits. ASIC Design using FPGA and PLDs,

ICT 6404: Real Time Computing for Embedded System *(Theory: 3 Hours/Week, Credit: 3.0)*

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 real time, concurrency issues, Real-time programming.

ICT 6405: Advanced Embedded System Design *(Theory: 3 Hours/Week, Credit: 3.0)*

Embedded System Concept: Hardware design for embedded systems, Software development for embedded systems, Network based embedded systems, Sensors and Transducers for embedded systems, Case study on advanced embedded system, Co-design using FPGAs, Multiprocessor systems, Case study on multiprocessor systems. **Introduction to digital control**: Its use within embedded systems, Case study on digital control in embedded systems. **Design examples**: a telephone PBX, Personal Digital Assistant (PDA).

ICT 6406: Soft Error Tolerance *(Theory: 3 Hours/Week, Credit: 3.0)*

Definition and Types of soft errors: benign faults, detectable unrecoverable errors, silent data corruption, soft error rates, critical charge. **Sources of soft errors**: external sources- alpha particle from package delay, cosmic rays induced neutron interaction, low energy neutron interaction with BPSG, internal sources- IR or L di/dt supply noise, power transients, capacitive or inductive crosstalk, risks of soft errors, soft error's impact on system reliability, affected computing structures. **Soft errors mitigation approaches**: comparison between model based mitigation approach and mitigation in implemented system, process technology solutions, software based approaches, and hardware based approaches, analyzing soft errors risks minimization at the system design phase, complexity analysis, severity analysis, criticality analysis and ways to minimize criticality.

ICT 6501: Speech Processing *(Theory: 3 Hours/Week, Credit: 3.0)*

Speech production models: Acoustic theory of speech production, discrete-time speech model, lossless model of the vocal tract, Speech perception. **Digital processing of speech signals**: Short-term processing of speech, linear prediction analysis, spectral analysis. **Speech coding**: LPC, MRA, enhancement, human auditory system, quality assessment, speech synthesis, Speaker recognition and verification systems.

ICT 6502: Speech Recognition *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction to Modeling human speech perception: Auditory, neural and cognitive processing, pattern matching, linguistic processing. **Representations of speech signal**: Band pass filter energies, formants, LPC and ARMA, cepstrum and mel-cepstrum, auditory model based representations, difference coefficients, Comparison of parametric representations. **Recognition modes and modalities**: Speaker dependency, isolated and continuous words, vocabulary size, speaking environment, perplexity, real-time operation, Stochastic models, linguistic models, prosodic knowledge sources. **Knowledge-based approaches**: Templates versus features, segmentation, labeling, fuzzy reasoning. **Stochastic approaches**: Hidden Markov Models (HMM), training and testing algorithms. **Connectionist approaches**: Neural networks, learning algorithms. **Applications**: Dictation systems, voice- voice-based communications, system control, security systems, speaker verification.

ICT 6503: Machine Translation *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction: Statistical versus structured natural language processing (NLP), basic statistics and statistical model, linguistics essentials, corpus-based NLP. **Models and techniques**: Collocations, statistical Inference, word sense disambiguation, lexical acquisition, Markov models. **Grammar:** Part-of-speech tagging, probabilistic context free grammars, probabilistic parsing. **Applications and techniques**: Statistical alignment, clustering, information retrieval, text categorization.

application domains: RTOSs for image processing embedded RTOSs for VoIP, RTOSs for fault-tolerant applications, RTOSs for control systems.

ICT 6106: Data Warehousing and Mining *(Theory: 3 Hours/Week, Credit: 3.0)*

Data warehousing and OLAP Technology: Introduction, multidimensional data model, Data warehouse architecture and implementation. **Data processing**: Data cleaning, Data integration and Transformation, Data reduction, Data discretization and hierarchy generation, Data compression techniques. **Data warehousing and Decision support**: Multidimensional database design, Aggregation queries, views and decision support, vie materialization and maintenance, indexing on OLAP. **Data mining primitives**: Data mining tasks, Characterization and comparison, Mining rules, tree structured rules. **Clustering and complex type data mining**: Types of clustering, methods of clustering and its details, mining spatial database, mining multimedia database, time series data, text data and web data.

ICT 6201: Web Engineering *(Theory: 3 Hours/Week, Credit: 3.0)*

Distributed Systems Infrastructure and Architectural Models: Basic Terminology, Networks, Internet, Intranet and Extranet, Client/Server Computing Paradigm, Open Systems and Communication Protocols, Communication Systems and Protocols. **Distribute Computing**: Models and Architectures, Open Systems, OSI Model. **Distributed Objects and Middleware**: Middleware, Views, Definitions, Functions, Middleware for Distribution, Distributed Objects Model, Interfaces and Interface Definition Language (IDL), Component Object Model (COM) and Distributed COM (DCOM), System Object Model (SOM) and Distributed SOM (DSOM). **Web and Programming**: Web Elements, Browser and Web Document, Static, active and dynamic pages, Programming paradigms and Web programming, Object-oriented vs. Object-based programming, Tasks suitable for programming on the Web, Application Programming Interface (API), Sockets. **Client and Server Implementation CGI**: Definition, Characteristics, CGI Programming Mechanism, GET and POST methods.

ICT 6202: Advanced Computer Networking *(Theory: 3 Hours/Week, Credit: 3.0)*

The TCP/IP protocol stack: IP, ARP, TCP and UDP, DNS, ICMP, Internet addressing, routing, IP multicast, RSVP, Next Generation IPIpng. **Interior gateway protocols**: RIPv2, IGRP, EIGRP, OSPF. **Wireless**: Radio basics, satellite systems, WAP, current trends, issues with wireless over TCP. **Congestion control**: control, avoidance, control and avoidance Algorithms, congestion in the Internet. **Network Security**: IP security, firewalls, Management: Quality of service (QoS), network vs. distributed systems management, integrated service, differentiated service, protocols, web-based management.

ICT 6203: Network Management and Security *(Theory: 3 Hours/Week, Credit: 3.0)*

Network Concept: Network operating system, streaming technology, Inter process communication (IPC) between application programs, Abstract Syntax Notation One (ASN.1). **Network Protocols**: TELNET, File Transfer Protocol (FTP), Simple mail transfer protocol (SMTP), Simple Network Management Protocol (SNMP), network programming, socket-level interface, algorithm and issues in client / server software design, Installation, Administration and management of commercial network software packages. **Networks Services**: Network information service (NIS) and network file system (NFS), State-of-the-art network management tools and systems, high speed LAN, MAN, network management and troubleshooting techniques.

ICT 6204: Advanced Network Security *(Theory: 3 Hours/Week, Credit: 3.0)*

Issues of Network security, Threats to Network security: tampering, wiretapping, impersonation, hacking, cracking. **Phishing**: Phishing as a cyber-crime, Technical Trends in phishing attacks, understanding and defending phishing attacks, social engineering and its impact on phishing. **ID Theft:** Definition of ID Theft, Possible ways of ID theft, preventing ID theft, Two-factor authentication, Authorization mode based access controls. **Firewalls**: Firewall architecture, packet filters, stateful inspection firewalls, application-proxy gateway firewalls, dedicated proxy servers, hybrid firewalls, Network Address Translation (DNAT and SNAT), Port Address Translation (PAT), De-militarized Zone (DMZ), Virtual Private Networks (VPN), Intrusion Detection System (IDS), Intrusion Prevention System (IPS), Firewall administration, Firewall positioning policy. **Secure network devices**: secure modems, Dial-back systems, crypto-capable Routers. Risk Management: Effective strategies, business process protection through assessment, planning and recovery. **Internet Vulnerabilities**: Operating Systems, Cross platform Applications, Network Devices, Security policy and personnel (Inside attacks and outside attacks), Zero day attacks prevention and recovery, Web and E-commerce security.

ICT 6205: Computer Security *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction, aspects and mechanisms of security; **Cryptography**: Mechanisms of classical cryptography, Private key cryptography including AES and DES, Public key cryptography including RSA and ElGamal cryptosystems, Digital Signature including RSA and DSA, Hash functions including MD and SHA, Message authentication codes. **Security Protocols**: Key Exchange, Authentication, Authentication and Key Exchange, Secret splitting and secret sharing; **Program Security:** Attacks, Malware, Viruses and other Malicious Codes, Controls against program threats; **Networks Security:** Threats in networks, Network security controls, Firewalls, Intrusion detection system, Secure E-Mail, Web security; **Access Control**: Security models and access policies, Access Control in operating systems and databases. **Legal and Ethical Issues:** Protecting Programs and Data.

ICT 6206: Applied Cryptography *(Theory: 3 Hours/Week, Credit: 3.0)*

Overview of cryptography: terminology, steganography, computer algorithms, Protocol building blocks, one way function, hash function, digital signatures, random and pseudo random sequence generation. **Basic protocols**: key exchange, authentication, formal analysis of authentication and key-exchange protocols, secret splitting, secret sharing, cryptographic protection of databases. **Intermediate protocols**: time stamping services, subliminal channel, different types of signatures, computing with encrypted data. **Advanced protocols**: zero knowledge proofs, blind signatures, identity based public key.

ICT 6207: e-Commerce Systems and Security *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction: The importance of e-commerce security, Current threats facing organizations that conduct business online and mitigate these challenges. **Cryptography**: Cryptography review, public key certificates and infrastructures, authentication and authorization certificates, secure credential services and role-based authorization. **Security:** mobile code security, security of agent-based systems, secure electronic transactions, electronic payment systems, intellectual property protection, Law and Regulation.

ICT 6208: E-Governance *(Theory: 3 Hours/Week, Credit: 3.0)*

Overview of E-Government and E-Governance, Stages of E-Governance, National E- Governance Plan(NeGP), Mission Mode Projects and their implementation status, E-Governance, Introduction to E-Governance, Role of ICT in e-governance, Need, importance of E-governance, Categories of E-governance, Key Issues of E-Governance, Technology, Policies, Infrastructure, Training, Copyrights , Consulting Funds, E-governance Models, Model of Digital Governance, Broadcasting /Wider Dissemination Model Unit. Critical Flow Model, Interactive-service model/Government to-Citizen-to-Government Model (G2C2G), Major areas of E-governance Services. **Public Grievances:** Telephone, Ration card, transportation, Rural services Land Records. **Police:** FIR registration, Lost and found. **Social services:** Death, domicile, school certificates. **Public information:** employment, hospitals, railway. **Agricultural sector:** Fertilizers, Seeds, Utility payments Electricity, water, telephone. **Commercial:** income tax, custom duty, excise duty-Governance Infrastructure, stages in evolution and strategies for success, E-Governance Infrastructure, stages in evolution and strategies for success, Human Infrastructural preparedness, Challenges against E-governance, Study of E-governance initiatives in Indian states, E-readiness, Legal Infrastructural preparedness.

ICT 6301: Advanced Digital Communication *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction: Characteristics of different types of channels, storage channels, Digital modulation schemes. **Digital transmission**: Mapping, impulse shaping, receiver design, inter-symbol interference, eye diagram, noise, symbol error probability for multilevel transmission, partial response technique, Equivalent baseband channel, Equalizer, adaptive equalizer, System design with joint Nyquist and matched filter condition, Orthogonal signals, correlation receiver and equivalent matched filter receiver. **Optimum detection:** Bayes, Maximum Likelihood (ML) and Maximum Aposteriori Probability (MAP) detection, ML symbol by symbol and sequence detection, soft and hard decision, Viterbi algorithm, Viterbi equalizer, Soft input decoding of convolutional codes, Principles of Code Division Multiplex and Access (CDMA), near-far problem, multi-user interference, synchronous orthogonal receiver, Time varying multipath channels for mobile communication, time and Doppler-variant transfer function, statistical channel description, scattering function.

ICT 6302: Advanced Optical Communication *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction to optical communication: Communication system, basic optical communication system, evolution of optical communication, advantages and disadvantages of optical communication. **Optical fiber waveguides:** construction, classification of fibers, modes of light propagation, transmission characteristics. **Optical sources:** Light emitting diodes (LED), semiconductor laser diodes. **Optical detectors**: p-n photodiode, p-in photo diode, and avalanche photodiodes (APDs). **Fiber connection**: Fiber joints and fiber couplers, wavelength MUX and DeMUX, optical add-drop MUX. **Optical amplifiers:** optoelectronic amplifiers, fiber amplifiers, Raman and Brillouin amplifiers, Optical modulation and detection schemes, direct and coherent detection receivers, Configuration, operation, noise sources, sensitivity and loss calculation, and performance curves, Digital and analog receivers. **Fiber nonlinearities**: Kerr effects–SPM, XPM, and FWM, Scattering effects–SRS and SBS. **Transmission link analysis**: point-to-point and point to-multi point links, system configuration, link power budget, line-coding schemes. **Optical multiplexing schemes**: WDM, OFDM, OTDM and OCDMA, Optical networks.

ICT 6303: Mobile and Wireless Communication *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction and History: Wireless Systems, Cellular Systems, Wireless LANs, Satellite Systems, Paging Systems. **Radio Propagation**: free space propagation, propagation mechanisms, link budget design using path loss model, outdoor propagation models, indoor propagation models, Introduction to small-scale fading, impulse response model of multipath fading, parameters of multipath channel, type of small scale fading, Rayleigh and Ricean Distribution. **Media Access Control**: FDMA, TDMA, and CDMA, Aloha, CSMA, MACA, GSM overview, Standards, services and structure. **GSM air interface physical layer**: physical channels, logical channels, frame structures, modulation, coding and interleaving, GSM signaling: Data link layer, radio resource management, mobility management, Handover, location update and roaming in GSM, Short message service (SMS), circuit switched data, General Packet Radio Service (GPRS), Enhanced GPRS (EGPRS). **CDMA Digital Cellular System (IS-95)**: Forward CDMA Channel, Reverse CDMA Channel, Satellite mobile communications: History, Localization, Handover, Routing. **Broadcast System**: Unidirectional distribution systems, DAB architecture, DVB-container, WCDMA in 3rd generation.

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ICT 6504: Computational Linguistics *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction: Syntactic processing, Grammars and parsing augmented grammars, grammars for natural language, parsing, ambiguity resolution, 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 6505: Computer Graphics and Animations *(Theory: 3 Hours/Week, Credit: 3.0)*

Graphics Concept: Introduction to computer graphics, Viewing model. **Transformations**: Rotation, translation, and scaling, **Rendering techniques**: Scan conversion, clipping, filling polygon, Hidden line and hidden surface removal, Illumination and shading, texture mapping, **Animation techniques**: Mesh based system, skeletal animation system, Animation models, fractals.

ICT 6506: Computer Vision *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction: Goals of computer vision, Methodologies, Main approaches and directions, Applications, Relations with other fields. **Techniques for Image Acquisition:** Monocular and multiple view vision, active and passive vision and range images. **Image Processing:** Sources of image degradation, mathematical description and classification of noise filtering techniques. **Feature Extraction and Grouping:** Edge detection, corner detection, histogram and thresholding techniques, curve fitting, hough transform, active contour, grouping and segmentation. **Camera Calibration**: Classification of camera parameters, lens properties and factors affective image capture, calibration algorithms, epipolar geometry, essential and fundamental matrices, eight point algorithm, rectification, applications. **Stereo:** 3D Shape from Two or More Images. Correspondence problem, sparse and dense stereo, common assumptions used in matching, dynamic programming, and visual cues. **Motion Analysis:** 3D Shape and Motion from Two or More Images. **Optical Flow:** Computing shape and motion from optical flow. **Object Recognition and Location:** Classification and methodologies of major approaches face location, face recognition.

ICT 6507: Multimedia Technologies and Applications *(Theory: 3 Hours/Week, Credit: 3.0)*

Multimedia data in digital format and their properties, color image models, color palettes. Human visual and auditory perception, multimedia compression algorithms and standards, compression techniques, principles and techniques of animation, creating animated scenes, video and audio image analysis, broadcast video standards, video capture, recording format, audio file formats MIDI, sound editing, interactive video production, programming multimedia system, authoring systems.

ICT 6508: Computer Applications in Medicine and Diagnosis *(Theory: 3 Hours/Week, Credit: 3.0)*

Data Acquisitions and Processing: Computerized bio-signal (ECG, EMG and EEG) data acquisition, medical data storage and retrieval, signal and images processing. **Biomedical Equipments:** Computers in patient monitoring, physiological monitoring, automated ICU, computerized arrhythmia monitoring. **Modeling and Simulation:** Computers in medical systems modeling, radiotherapy, drug delivery system, Physiological system modeling and simulation. **Classification techniques:** Pattern recognition techniques for medical image classification, Machine learning concepts, **Telemedicine.**

ICT 6509: Medical Imaging Systems *(Theory: 3 Hours/Week, Credit: 3.0)*

Medical Radiation Imaging: X-ray generations-interactions, x-ray attenuation concepts, x-ray projection imaging, digital mammography. **Computed tomography:** CT generations, image reconstruction basics, Fourier slice theorem, filtrated back-projection algorithm, common artifacts and remedy measures, resolution concepts. **Magnetic Resonance Imaging:** MR principles, pulse sequences, MR image reconstruction. **Ultrasound Imaging:** Ultrasound imaging principles, Doppler technique, elastography. **Nuclear imaging**: PET, SPECT.

ICT 6510: Bioinformatics *(Theory: 3 Hours/Week, Credit: 3.0)*

The Biological Foundations of Bioinformatics, Biological Databases, Sequence Comparisons and Sequence-Based Database Searches, The Decoding of Eukaryotic Genomes, Protein Structures and Structure-Based Rational Drug Design, Systems Biology, The Functional Analysis of Genomes, Comparative Genome Analyses, Bioinformatics Algorithms.

ICT 6601: Soft Computing *(Theory: 3 Hours/Week, Credit: 3.0)*

Introduction: Concepts of Fuzzy Logic, Fuzzy Logic and Genetic Algorithms. **Natural Computations**: Introduction, Adaptive Models and Machine Learning. **Supervised Learning:** Feed Forward Neural Networks, Radial basis functions, Fuzzy Neural Networks. **Unsupervised Learning**: Clustering Techniques, Self Organizing Maps. **Evolutionary Computations**: Genetic Programming, Learning Classifier Systems. **Reinforcement Learning**: Introduction, Framework, Model, applications, Q-learning, dynamic programming, montecarlo methods.

ICT 6602: Bio-inspired Computing Techniques *(Theory: 3 Hours/Week, Credit: 3.0)*

History and Philosophy of Bio-Inspired Computing, Evolutionary Computation: Natural Evolution, Principles of Evolutionary Algorithms, Genetic Algorithms, Evolution Strategies, Evolutionary Programming, Genetic Programming. **Molecular Computing**: Molecule and Molecular Computing Basics, Conformation-Based Computing, Molecular Recognition, Chemical-Based Computing, DNA Computing, Bioelectronics and Bio-computers. **Neural Computing**: Biological Neuron and its Computational Model, Feed Forward Neural Networks, Complex-Valued Neural Networks, Spiking Neural Networks. **Development Systems**: Rewriting Systems,

Synthesis of Developmental Systems, Artificial Evolutionary Developmental Systems, Evolutionary Rewriting Systems, Evolutionary Developmental Programs. **Immunological Computation**: Immunology Basics, Theoretical Models of Immune Processes, Immunity-Based Computational Models, T Cell–Inspired Algorithms, B Cell–Inspired Algorithms. **Behavioral Systems**: Behavior in Cognitive Science, Behavior in Artificial Intelligence, Behavior-Based Robotics, Biological Inspiration for Robots, Robots as Biological Models. **Robot Learning Collective Intelligence:** Phenomena and Models of Biological Self-Organization, Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC) Algorithm.

ICT 6700: Special Study in Information and Communication Technology

(Theory: 3 Hours/Week, Credit: 3.0)

Course content and title would be designed by the teacher, who is offering the course.