Computer engineering syllabus

Group A - Compulsory examinations (five required)

25-Comp-A2 Digital Systems Design

Boolean algebra. Design of combinatorial and sequential logic. Implementation using simple gates. Programmable logic devices and gate arrays. Characteristics of digital integrated circuit families. Analysis and design for controllers, processors, and memories. Microprocessors, including components, data flow, signals, and timing. Small system design, interconnection of associated devices. Computer interfacing, including parallel and serial I/O, interrupts and DMA. Common bus structures.

Textbooks (most recent edition is recommended):

- Roth, Charles, Kinney, Larry L. Fundamentals of Logic Design, Cengage Learning.
- Thorne, Michael. Computer Organization and Assembler Language Programming for the IBM PC and Compatibles, Addison Wesley.

25-Comp-A3 Computer Architecture

Architecture, programming and I/O. Computer structure and typical processor architecture. CPU and memory organization, buses. Characteristics of I/O and storage devices. Processing unit and controller design, hardwired and microprogram control. Instruction sets and addressing modes; assembly language programming, I/O and interrupt servicing.

Textbooks (most recent edition is recommended):

- William Stallings, Computer Organization and Architecture, 10th Edition, Pearson
- Hayes, Computer Architecture and Organization, 2nd Edition, McGraw-Hill
- Hennessy & Patterson, Computer Architecture: A Quantitative Approach, 2nd Edition

25-Comp-A4 Program Design and Data Structures

Programming language syntax and semantics. Design of structured and modular programs in a high level language (C, C++). Basics of object-oriented programming: classes. Non-numerical processing. Design and construction of programs involving structured data: arrays, stacks, queues, lists, trees, and records.

Textbooks (most recent edition is recommended):

- Carrano and Henry, Data Abstraction and Problem Solving with C++, seventh edition
- Deitel & Deitel, C++: How to Program, tenth edition
- Weiss, Data Structures and Algorithm Analysis in C++, fourth ed.
- Addison-Wesley Hanley, Essential C++ for Engineers and Scientists
- Wiley Wunder & Roberts, Developing Java Software

25-Comp-A5 Operating Systems

Operating system principles, components, and programming. Design and implementation of operating systems. Synchronization of concurrent processes, resource allocation, scheduling, protection, and privacy. Data, task, and job management: loading, linking; I/O control. Multi-core, multi-threading and multi-processing. Virtualization, hypervisors and containers. Real-time aspects. Basic characteristics of modern operating systems: u=Unix, Windows.

Textbooks (most recent edition is recommended):

- Suberschatz & Galvin, Operating System Concepts, 9th Edition
- Addison-Wesley Tanenbaum, Modern Operating Systems

- Stallings, Operating Systems Internals and Design Principles, 8th ed.

25-Comp-A6 Software Engineering

Software cycles and requirements analysis. Design, implementation, test, verification and validation, documentation, quality assurance, control and life-cycle management of correct, reliable, maintainable, and cost effective software. Current design methodologies, including modularization, graphical design tools, design in high-level languages, and data flow driven designs. Planning and management of software projects. Software maintenance and configuration management.

Textbooks (most recent edition is recommended):

- Sommerville, Software Engineering, 10th Edition
- Pressman, Software Engineering: A Practitioners Approach, 8th Edition, McGraw-Hill

Group B - Optional Examinations (three required)

25-Comp-B1 Advanced Computer Architecture

Architecture of high speed workstation and personal processors and systems. Instruction set design for pipelined machines. Caches. Multiple processor architectures, highly parallel machines, systolic arrays, neural networks, multitasking machines, real-time systems, interconnection of multiple processor systems. Architectures for specialized purposes, array processors, vector processors. Virtual machines.

Embedded systems and control.

Textbooks (most recent edition is recommended):

- Hennessy and Patterson, Computer Architecture: A Quantitative Approach, 5th ed, Morgan Kaufmann

25-Comp-B2 Principles of VLSI

Very large scale integrated circuits. Fabrication processes in CMOS and BICMOS. Simplified design rules. Design methodology. Static and dynamic logic, multiphase clocking. Memory elements and memory structures. Gate arrays and standard cell technology; placement and routing. Programmable logic devices. I/O devices. Testing.

Textbooks (most recent edition is recommended):

- Chen, CMOS Devices and Technology for VLSI
- Rabaey & Chandrakasan, Digital Integrated Circuits, 2ED, Pearson
- Glasser & Dobberpuhl, The Design and Analysis of VLSI Circuits
- Jack & Denyer, Introduction to MOS LSI Design

25-Comp-B3 Data Bases and File Systems

Concepts and structures for design and implementation of data bases and file systems. Data models, data normalization, data description languages, query facilities, data integrity and reliability, concurrency. Data bases: hierarchical, network and relational databases; data organization. Relational query languages: relational algebra and calculus, SQL. Relational database design. Transaction processing, query processing, reports. Security and integrity; concurrency control. File organization: sequential, indexed and direct access, multiple key, and hashing. File processing: records, files, compaction. Sorting, merging and updating files. Algorithms for inverted lists, multilist, indexed sequential and hierarchical structures. File I/O: control, utility, space allocation, and cataloguing. Index organization. NoSQL (e.g. MongoDB) databases

Textbooks (most recent edition is recommended):

- Elmasri & Navathe, Fundamentals of Database Systems, 7th Edition
- Connolly and Begg, Database Systems: A Practical Approach to Design, Implementation and Management, 4th edition, Addison-Wesley
- Date, An Introduction to Data Base Systems, 6th Edition

25-Comp-B4 Computer Graphics

Hardware and software systems for graphics. Input and output devices, display devices. Techniques for describing and generating image. Object modeling and display techniques. Transformations in two and three dimensions: scaling, translation, rotation, clipping and windowing. Visual realism: perspective, visibility, hidden surface elimination, illumination, shading and rendering. Graphic software and data structures, display data structures and procedures, efficient algorithms. Current graphics standards. Use of XR content (VR – virtual reality; AR – augmented reality) on mobile devices and optical headsets. Optional inclusion of video formats and streaming and of animation techniques.

Textbooks (most recent edition is recommended):

- Eck, D.J. Introduction to Computer Graphics, self-published (free non-commercial use).
- Hughes, John, van Dam, Andries, et al. Computer Graphics: Principles and Practice, Addison-Wesley.

25-Comp-B5 Computer Communications

Data communications, including signals, modulation and reception. Error detecting and correcting codes. Including circuit and packet switching. Multiplexing, including time, frequency and code division multiplexing. Digital networks, including ISDN, frame relay and ATM. Protocols: the ISO/OSI reference model, X.25. Internetworking and router-based networks: the TCP/IP suite of protocols, routing and flow control, Internet addressing and domain names. Local area networks, topologies, access schemes, medium access and logic layers; CSMA/CD and token ring protocols; segmented and hubbed LANs. Wireless transmission technologies (e.g. Wi-Fi, cellular networks.) This syllabus requires knowledge of linear systems as described in 16-Elec-A1.

Textbooks (most recent edition is recommended):

- Stallings, W., Data and Computer Communications, 10th Edition, Pearson
- Wiley Comer, Internetworking with TCP/IP Volume I: Principles, Protocols, and Architecture
- Kurose & Ross, Computer Networking: A Top-Down Approach, 7th ed, Pearson
- Saadawi, Amman & El Hakeem, Fundamentals of Telecommunication Networks, Prentice-Hall

25-Comp-B6 Computer Control and Robotics

Discrete-time and digital control systems. Z-transform based and state space methods. Principles of digital control. Digital controllers and components. Controller software. Industrial and robotic systems. Descriptions of 3D space, geometry of robotics manipulators. Transducers and interfacing. This syllabus requires knowledge of linear systems as described in 16-Elec-A1.

Textbooks (most recent edition is recommended):

- Moudgalya, Digital Control, Wiley-Interscience.

25-Comp-B7 Digital Signal Processing

Theory of discrete-time linear systems. Digital filtering. Discrete Fourier analysis. Application to voice and image processing, communications, etc. Hardware for digital signal processing, including digital signal processors. This syllabus requires knowledge of linear systems as described in 16-Elec-A1.

Textbooks (most recent edition is recommended):

- Blandford and Parr, Introduction to Digital Signal Processing, Pearson
- Strum & Kirk, First Principles of Discrete Systems and Digital Signal Processing

25-Comp-B8 Computer Integrated Manufacturing

The integration of mechanical, electronic and informational components in manufacturing. Hierarchical and distributed computer control, including hardware and software. Collecting, controlling, processing and disseminating data. Sensors and tool control, station control. “Factory floor” local area networks and protocols; manufacturing data bases. Process design and operation. CAD/CAM, manufacturing resource planning, and numerical control (CNC). Additive or subtractive manufacturing processes (e.g. 3D printing, sintering, milling, laser and ablative technologies, fabricator shops)

Textbooks (most recent edition is recommended):

- Rehg & Kraebber, Computer Integrated Manufacturing, 3rd ed, Pearson

25-Comp-B9 Artificial Intelligence and Expert Systems

Concepts of artificial intelligence. Overview of knowledge-based and expert systems. Logic programming. Programming languages commonly used for AI and expert system implementation. Knowledge representation. Rule-based and object-based systems.

Textbooks (most recent edition is recommended):

- Winston, Patrick Henry. Artificial Intelligence, Addison Wesley.

25-Comp-B10 Distributed Systems

Characteristics of distributed systems. Networked vs. centralized systems. Fundamental concepts and mechanisms. Client-server systems. Process synchronization and interprocess communications. Principles of fault tolerance. Transaction processing techniques. Distributed file systems. Operating systems for distributed architectures. Security.

Textbooks (most recent edition is recommended):

- Tanenbaum & Van Steen, Distributed Systems: Principles and Paradigms, Pearson
- Shuey, R.L., Spooner, D.L., and Frider, O., The Architecture of Distributed Computer Systems, Addison-Wesley
- Mullender, S. (Editor), Distributed Systems, 2nd Edition, Addison-Wesley

25-Comp-B11 Advanced Software Design

The design and programming aspects of the construction of large software systems. Advanced object-oriented design. Language support for modular programming, visual programming systems, GUI design and implementation.

Textbooks (most recent edition is recommended):

- Dasgupta & Dimitriou, Algorithms, McGraw-Hill

25-Comp-B12 Computer Security

Types of threats, terminology, network basics, internet fraud, theft, cyber stalking, DoS attacks, malware, hacking, industrial espionage, encryption and cryptography, security technology: accvess control, virus scanners, firewalls, IDS, certificates, SSL/TLS, VPN, Wi-fi security; security policies; forensics.

Textbooks (most recent edition is recommended):

- Bishop, Introduction to Computer Security, Addison-Wesley
- Easttom, Computer Security Fundamentals, third edition
- Anderson, Security Engineering, second ed, https://www.cl.cam.ac.uk/~rja14/book.html

25-Comp-B13 Mechatronic Design

Microprocessors microcontrollers, architectures, programming languages, embedded software and event-driven control, software design, communications and protocols, peripherals: sensors and interface circuits.

Textbooks (most recent edition is recommended):

- Carryer et al, Introduction to Mechatronic Design, Pearson

25-Comp-B14 Discrete Mathematics

Logic: propositional equivalences, predicates and quantifiers, sets, set operations, functions, sequences and summations, the growth of functions. Algorithms: complexity of algorithms, the integers and division, matrices. Methods of proof: mathematical induction, recursive definition. Basics of counting: pigeonhole principle, permutations and combinations, discrete probability.

Recurrence relations: inclusion-exclusion. Relations and their properties: representing relations, equivalence relations. Introduction to graphs: graph terminology, representing graphs and graph isomorphism, connectivity, Euler and Hamilton paths. Introduction to sorting.

Textbooks (most recent edition is recommended):

- Rosen, Kenneth H. Discrete mathematics and its applications, Tata McGrawhill Education.
- Balakrishnan, V. K. Introductory Discrete Mathematics, Dover.
- Levin, Oscar. Discrete Mathematics - An Open Introduction, open source.

25-Comp-B15 Computer Room Design (or Data Centre Design)

Considerations for creation of data centres with high density computing components. Not all topics required, but would include power, cooling, fire suppression and networking as mandatory; Sizing and configuration of power supply and backup (UPS/battery, generator, dual power supplies); Sizing cooling and configuring ventilation (hot / cold corridors, cooling capacity, power demands); Networking for high density computing equipment; Configuration of high density compute - blades & chasses ; GPU (graphics processing units); Fire suppression methods and techniques; Floor layout for high density computing; Physical security; Redundancy and backup of data, systems, and networking.

Textbooks (most recent edition is recommended):

- EN 50600-1 Information technology - Data centre facilities and infrastructures - Part 1: General concepts, CENELEC.'

25-Comp-B16 Electronics

Formerly A1

Devices: circuit models and characteristics. Integrated circuits. Diodes, rectifiers, and wave shaping networks. Field effect and bipolar transistors: small-signal and AC analysis. Single-stage amplifier design. Operational amplifiers and applications. Large-signal analysis, wave shaping and bistable circuits including multivibrators, triggers, and waveform generators. Digital electronics including basic logic gates and memory elements. Hybrid analog/digital devices including A/D and D/A converters.

Textbooks (most recent edition is recommended):

- Sedra, Adel, Smith, Kenneth. Microelectronic Circuits, Oxford UP.