B.Eng. (Computer Engineering)

Content of Subjects

Applicable to Students Matriculating in 2011 or later

FIRST YEAR

CE1001 DISCRETE MATHEMATICS
Acad Unit: 3
Pre-requisite: Nil

Elementary number theory; Sets; Predicate logic; Linear recurrence relation; Relations; Functions; Graphs; Complex numbers, vectors and matrices; Elementary Combinatorics

CE1002 INTRODUCTION TO COMPUTING SYSTEMS
Acad Unit: 3
Pre-requisite: Nil

Introduction; Computer Pioneers and their contributions; Evolution of Computers – Part I; Basic CPU operation and programming language evolution; Evolution of Computers– Part II; CPU Performance Enhancement techniques; Programming Languages and Database; Programming Paradigms; The internet; Networks and communications; Multi-tasking and Operating Systems; Classifications of Computer Systems; Computing Trends; e-learning

CE1003 INTRODUCTION TO COMPUTATIONAL THINKING
Acad Unit: 3
Pre-requisite: Nil

Computing and Algorithms; Introduction to Python; Basic syntax and meaning; Variables, Data types, and Operators; More on numbers and built-in functions; Flow control; Program Development Issues (supplementary); Strings and character access; Composite types; User defined functions and modules; File management; Exceptions

CE1004 GREAT IDEAS IN COMPUTING
Acad Unit: 2
Pre-requisite: Nil

Applications and directions in scientific computing; The impact of personal computer; Highly-Integrated microcontrollers and their applications; Neural Networks and Artificial Intelligence; The influence of Military activities on modern computing; Computers, telecommunications and environmental impact; How computers are used in financial markets; Memory technologies and prospects

CE1005 DIGITAL LOGIC
Acad Unit: 3
Pre-requisite: Nil
Binary integers and arithmetic; Boolean Variables and Logic; Combinatorial circuits; Implementation technologies; Digital design using hardware description languages; Sequential circuits; Sequential circuits to building blocks; Finite state machines

**CE1006 COMPUTER ORGANISATION AND ARCHITECTURE**

Acad Unit: 3  
Pre-requisite: CE1005 (can be taken concurrently)  

Computer Hardware Decomposition; Data Representation, Memory Allocation and Access; Central Processing Unit; Assembly Programming and Instruction Set Architecture; High-level Software to Low-level Instructions; Computer Memory; Data Transfer and Input/Output (I/O) Techniques; Computer Arithmetic; Measuring system performance; Towards higher speed

**CE1007 DATA STRUCTURES**

Acad Unit: 3  
Pre-requisite: CE1003

Basic Constructs in CC program structure, Syntax and semantics; Built-in Data Structures; Recursion; Memory Management in C; Linked Lists; Stacks and Queues; Tree Structures; Implementing other data abstractions

**CE1008 ENGINEERING MATHEMATICS**

Acad Unit: 3  
Pre-requisite: Nil

Precalculus: Functions and graphs; Limits and continuity; Derivatives and applications; Integrals and applications; First order differential equations; Infinite series; Descriptive statistics; Probability theory

Probability and sampling distributions; Inferential statistics; Experimental and Numerical Methods

**CE0001 ENGINEERS AND SOCIETY**

Acad Unit: 3  
Pre-requisite: Nil

This course raises issues pertinent to engineers as professionals as well as members of society. It discusses the requirements and issues of the IT profession, examining the key role professionals play with their contributions to society. Current concerns will be raised of interest to any person living in Singapore.
SECOND YEAR

CE2001 ALGORITHMS
Acad Unit: 3
Pre-requisite: CE1001, CE1007
Introduction to algorithms, basics for analysis of algorithms, sorting, searching, graphs, basic computability and complexity theory

CE2002 OBJECT ORIENTED DESIGN AND PROGRAMMING
Acad Unit: 3
Pre-requisite: CE1007
Introduction to Object Orientated Programming; Interface and implementation; Designing with Classes and Objects; Inheritance and polymorphism; Object Relationships; Framework and Reuse; Persistent Objects; Design patterns; Object Oriented Programming Language

CE2003 DIGITAL SYSTEMS DESIGN
Acad Unit: 3
Pre-requisite: CE1005
Review of Hardware Description Languages; Real-World Arithmetic; Control and Datapath design; Register Transfer Level (RTL) design in Verilog; Digital Design on FPGAs; Testbenches and Testing Strategies; Using Intellectual Property (IP)

CE2004 CIRCUITS AND SIGNAL ANALYSIS
Academic Unit: .3
Pre-requisite: CE1008
DC Signal Analysis; AC Signal Analysis; Signals; Systems and time-based system analysis; Frequency-based System Analysis

CE2005 OPERATING SYSTEMS
Acad Unit: 3
Pre-requisite: CE1007
Overview of Operating Systems (OS); Processes and Threads; Process Scheduling; Deadlock and Starvation; Memory Organization; Virtual Memory Management; File System Organization and Implementation; Input/Output (I/O) Management and Disk Scheduling; Issues in Real-time Operating Systems; Protection and Security

CE2006 SOFTWARE ENGINEERING
Acad Unit: 3
Pre-requisite: CE2002 (can be taken concurrently)
Introduction to Software Engineering; Software Engineering Process; Introduction to Requirements; Introduction to Software Specifications; Software Design and Construction; Testing and Integration; Software Maintenance; Software Project Management; Software Quality; Dependability and Security
CE2007 MICROPROCESSOR-BASED SYSTEMS DESIGN

Acad Unit: 3
Pre-requisite: CE1006 & CE2004 (can be taken concurrently)

Microprocessor landscape; Microprocessor packages, signals and interfacing – Part 1; Introduction to ARM Cortex-M Architecture and Programming; Peripherals, interfaces and applications – Part 1; Analog signal conditioning and Interfacing Displays; Signals and interfacing – Part 2; Peripherals, interfaces and applications – Part 2; Semiconductor memory technology and characteristics; Fabrication; System Design Issues; Further integration and programming

CE0002 GREEN COMPUTING

Acad Unit: 3
Pre-requisite: Nil

Introduction to Green Computing; eLearning; Energy; Green design; Green manufacturing; Green use; Green disposal; Other issues; Common sense approaches to green computing; Green applications
THIRD YEAR

CE3001 ADVANCED COMPUTER ARCHITECTURE
Acad Unit: 3
Pre-requisite: CE1006
Introduction to Computer System; The CPU Architecture; Performance Enhancements & Instruction-Level Parallelism; Memory Systems; Data-Level Parallelism in Vector, SIMD, and GPU Architectures; Multiprocessors and Thread-Level Parallelism; Warehouse-Scale Computing; Exploiting Request-Level and Data-Level Parallelism; Future directions

CE3002 SENSORS, INTERFACING AND CONTROL
Acad Unit: 3
Pre-requisite: CE2004
Overview of electronic instrumentation and control systems; Sensors and Transducers; Signal Conditioning; Digital Interfaces; Introduction to control system; Design of Digital Control; Linear Discrete Data System

CE3003 MICROCONTROLLER PROGRAMMING
Acad Unit: 3
Pre-requisite: CE2005
Integrated Development Environments; Microcontroller Architectures; Efficient Real-time 'C' Programming Techniques; Linking 'C' with Assembler and Libraries; Programming Peripherals and Subsystems; Handling Multiple Tasks in Real-Time; Real-Time Operating Systems; Compiler optimizations

CE3004 MULTIDISCIPLINARY DESIGN PROJECT (MDP)
Acad Unit: 4
Pre-requisite: At least Third Year Standing
MDP is a group-based design and development project undertaken by a mixed group of students comprising of undergraduates from the CE and CS programmes. The project is practical-oriented and multi-disciplinary in nature, requiring system level integration of sub-systems developed by different team members. Topics covered will include Microprocessors, Signals and Interfaces, Sensors and Communication, Software engineering, Data structures and Algorithms, Open-source frameworks.

NB: MDP is to be done over one semester by students who have reached at least a year 3 standing. Eligible students will be automatically registered by the school and will be allocated to their respective project group based on a composition of students from different programmes. Students cannot choose to defer the MDP.

Course Schedule: Twelve two-hour weekly slots and five full days during the entire recess week.

The group-based nature of MDP makes it important that the disruptive absence of members is strongly discouraged. Attendance for all scheduled MDP activities is thus compulsory. Students who do not satisfy at least 80% of the overall attendance without valid reasons (e.g. MC) will be deemed to have failed MDP. Students who miss more than 50% of the scheduled MDP sessions will not be deemed to have fulfilled the learning outcomes of MDP and they will be required to re-take MDP in the next available offering. In other words, an "I" will be reflected in the result transcript for MDP.
CE3005 COMPUTER NETWORKS

Acad Unit: 3
Pre-requisite: CE1008

Computer Network Concepts; Network Types and Performances; Data Link Layer; Local Area Networks; Network Layer; Transport Layer; Application Layer

CE3006 DIGITAL COMMUNICATIONS

Acad Unit: 3
Pre-requisite: CE2004

Introduction; Signals and spectra; Baseband modulation, demodulation/detection; Band-pass modulation, demodulation/detection; Source coding; Channel coding; Challenges in communication system design

CE3007 DIGITAL SIGNAL PROCESSING

Acad Unit: 3
Pre-requisite: CE2004

Digital Signal Processors; Discrete-time Signals and Systems; Frequency Analysis of Signals and Systems; The Discrete Fourier Transform; Sampling and Reconstruction; FIR and IIR Filter Design
Digital Filter Structure
FOURTH YEAR

TECHNICAL ELECTIVES

CE/CZ4001 Virtual and Augmented Reality

Acad Unit: 3  
Pre-requisite: CZ2003

Introduction; Graphical Scene; Animation and Sensing; Light and Sound; Controlling Environment; Programming Scripts; Introduction to Augmented Reality; Displays for Augmented Reality; Tracking, Recognition and Registration; Rendering and Augmentation; Examples of Augmented Reality System

CE/CZ4002 VISUAL MEDIA COMPRESSION AND PROCESSING

Acad Unit: 3  
Pre-requisite: Nil

Introduction to media management & processing; Entropy coding; Digital image coding techniques; Motion Estimation; Digital video coding techniques; Advanced topics for visual signal compression; Image retrieval and indexing

CE/CZ4003 COMPUTER VISION

Acad Unit: 3  
Pre-requisite: Nil

Introduction to computer vision; Principles of Camera Systems; Image Enhancement in the Spatial domain; Image Enhancement in the Frequency domain; Colour; Edge Processing; Region Processing; Imaging Geometry; 3D Stereo Vision; Object Recognition

CE/CZ4004 3D MODELING AND ANIMATION

Acad Unit: 3  
Pre-requisite: CZ2003

Introduction; Computer Graphics Pipeline; Graphics Programming; 3D Shape Representation; Geometric Processing; Rendering; Basic Animation Techniques; Kinematic Animation; Physics Based Simulation; Motion Capture

CE/CZ4005 AUDIO AND SPEECH PROCESSING

Acad Unit: 3  
Pre-requisite: Nil

Introduction to audio and speech science; Principles of audio and speech science; Spectrograms; Linear Predictive Coding; Mel Frequency Cepstral Coefficients (MFCC); Gaussian Mixture Models; HMM models; Classification of audio signal
Acoustic modeling for speech recognition
CE/CZ 4011 PARALLEL COMPUTING
Acad Unit: 3
Pre-requisite: CZ/CE2001 & CZ/CE3001

Foundations & Theory; Distributed Memory Programming; Shared Memory Programming; Massively Parallel Programming; Synchronous computations

CE/CZ4013 DISTRIBUTED SYSTEMS
Acad Unit: 3
Pre-requisite: CZ/CE2005 & CE3005 or CZ3006

Characteristics of distributed systems and system models; Interprocess communication; Distributed objects and remote invocation; Distributed file systems; Peer-to-peer systems; Name services; Time and global states; Coordination and agreement; Replication and consistency

CE/CZ4015 SIMULATION AND MODELLING
Acad Unit: 3
Pre-requisite: CZ/CE1007 & CZ/CE1008

Introduction; Different Types of Simulation; Simulation World View and Simulation Software; Basic Probability and Statistical Models for Simulation; Random Numbers and Random Variate Generation; Input Modelling; Verification and Validation of Simulation Models; Output Analysis; Comparison of Alternative Designs; Queueing Models

CE/CZ4016 ADVANCED TOPICS IN ALGORITHMS
Acad Unit: 3
Pre-requisite: CZ2001

Analysis Techniques; Dynamic Programming; Search Techniques; Computational Geometry; Min Cut/Max Flow; Lower Bounds and NP-completeness; Approximation Algorithms and Heuristics; Randomized Algorithms

CE/CZ4021 PERVASIVE NETWORKS
Acad Unit: 3
Pre-requisite: CE3005 or CZ3006

The objective of this course is to introduce different types of wireless network technologies and some important mobile services and applications to support pervasive computing. The subject consists of two complementary components, i.e., wireless network protocol and mobility management. In the wireless network protocol part, various protocols in different layers designed to support wireless data transfer will be presented. In the mobility management, the required mechanisms to support data transfer with users' mobility will be discussed. After attending this course, the students will be able to appreciate the various technical challenges associated with wireless networking and develop a basic understanding of the solutions proposed to overcome the challenges, and the principles behind them. In addition, the students will acquire working knowledge of the principles of and issues related to location management, and mobile multimedia services.

CE/CZ4022 PERSONAL MOBILE NETWORKS
Acad Unit: 3
Pre-requisite: CE3005 or CZ3006
Fundamentals of Wireless Mobile Communications: concepts, challenges and components; radio frequency transmission, data and carrier signal components; channel bandwidth and data rate; modulation; signal propagation, data transmission (modulation, spread spectrum, multiple access); Overview of mobile networks, Wireless Personal Area Networks (WPAN); Wireless Local Area Networks (WLAN); Wireless Wide Area Networks (WWAN); cellular communications networks, satellite communications.

CE/CZ4023 ADVANCED COMPUTER NETWORKS

Acad Unit: 3
Pre-requisite: CE3005 or CZ3006

Top-Down View of Computer Networks; Application Layer Protocols; Multimedia Networking; Advanced Network Protocols; QoS and Traffic Management; Network Deployment and Design

CE/CZ4024 CRYPTOGRAPHY AND NETWORK SECURITY

Acad Unit: 3
Pre-requisite: CE3005 or CZ3006

The course aims at exposing computer engineering students to principles and efficient implementations of cryptographic techniques /components for protection of networked computers and secure communications over an open network. Coverage include: Threats and security services in an opened computer network; foundation mathematics underlying practical cryptographic techniques (basic number theory and algebraic finite fields); Established cryptographic algorithms including AES, RC4, RSA, and other public key algorithms that based on discrete logarithm of finite algebraic groups, Cryptographic hashes; Message authentications and block cipher chaining; Lightweight cryptography, Cryptographic protocols for authentication and key distribution; Key management. The course does not address other important network security techniques that are built upon firewalls, intrusion detections and security auditing. Students who dislike mathematics and logic (for reasoning) and/or computer arithmetic are advised to consider carefully when enrolling this course.

CE4051 EMBEDDED SYSTEMS DESIGN

Acad Unit: 3
Pre-requisite: CE2003, CE3001

What is Design; Meeting Design Constraints; Software Design (Modeling); Software Design (Analysis); Hardware Design (Modelling); Hardware Design (Implementation); Sensors and I/O Hardware/Software Co-Design; Hardware/Software Co-Design (Case study)

CE4052 EMBEDDED SYSTEMS DEVELOPMENT

Acad Unit: 3
Pre-requisite: CE/CZ2006 & CE/CZ3001

Introduction to Embedded Systems Programming; The Android Ecosystem; Software Design and Management; Profiling & Optimization; Hardware Acceleration; Multi-Threaded; Scheduling & Prioritisation; Advanced Topics

CE4053 EMBEDDED OPERATING SYSTEMS

Acad Unit: 3
Pre-requisite: CE/CZ2005
Embedded OS Introduction; Relevance of Embedded OS; Benchmarking Performance; Single-core Scheduling; Multi-core Scheduling; Resource/Data Sharing; Isolation through Virtualization; RTOS case-studies; Recent Trends

CE4054 PROGRAMMABLE SYSTEMS-ON-CHIP

Acad Unit: 3
Pre-requisite: CE/CZ2003

Intro to Programmable SoCs; The SoC Design Flow; SoC Compute Organizations; Communication and I/O Abstractions; Tuning SoCs; Memory Organizations; Advanced Optimization Topics; Design Space Exploration; SoC Project Management and Formulation

CE/CZ4062 COMPUTER SECURITY (SYSTEM SECURITY)

Acad Unit: 3
Pre-requisite: CE/CZ2005

This course is concerned with security mechanisms in modern computer systems. Concepts and Terminology; Security Models; Implementation of Mechanisms; User authentication; Case Studies; Operating system vulnerabilities; Software security

CE/CZ4064 SECURITY MANAGEMENT

Acad Unit: 3
Pre-requisite: CE/CZ2006

This course introduces network security at an elementary level. What is security and why is it necessary? ; Security management - systems, models and frameworks; Internal control, audit and security; Risk analysis; Business continuity planning; Information security, governance and the law