B.Eng. (Computer Science)
Course Contents
Applicable to Students Matriculating in 2016 onwards

FIRST YEAR

CZ1002 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

CZ1003 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

CZ1004 INVENTIONS AND INNOVATIONS IN COMPUTING

Acad Unit: 2
Pre-requisite: Nil

Binary operations; Von Neumann and Harvard architectures; Invention of semiconductor materials; Examples of simple and complex CPUs; Programming Paradigms and Languages, Compilers and Algorithms; Operating Systems; Internet and distributed computing; Social networks; Numerical methods for the approximate computer solution of otherwise intractable problems; Databases; Data Analytics; Computer graphics and animation; Graphics Processor Unit; Computer and data security; Program Verification, Testing, Reliability and Correctness.

CZ1005 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

CZ1006 COMPUTER ORGANISATION AND ARCHITECTURE

Acad Unit: 3
Pre-requisite: CZ1005 (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

CZ1007 DATA STRUCTURES

Acad Unit: 3
Pre-requisite: CZ1003

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

CZ1011 ENGINEERING MATHEMATICS I

Acad Unit: 3
Pre-requisite: Nil

Complex Numbers; Vectors; Matrices; Systems of Linear Equations; Descriptive statistics; Probability theory; Probability and sampling distributions; Inferential statistics; Experimental and Numerical Methods.

CZ1012 ENGINEERING MATHEMATICS II

Acad Unit: 3
Pre-requisite: CZ1011 (can be taken concurrently)

Precalculus; Limits and Continuity; Differentiation; Integration; Ordinary Differential Equations (ODE); Sequences and Series; Function approximation; Numerical differentiation and integration; Fourier Series; Fourier Transform

CZ0001 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.

MH1812 DISCRETE MATHEMATICS

Acad Unit: 3
Pre-requisite: Nil

Elementary number theory; Propositional logic; Predicate logic; Proof techniques; Sets; Linear recurrence relation; Relations; Functions; Graphs; Elementary Combinatorics

SECOND YEAR

CZ2001 ALGORITHMS

Acad Unit: 3
Pre-requisite: CZ1007, CZ1012, MH1812

Introduction to algorithms, basics for analysis of algorithms, sorting, searching, graphs, basic computability and complexity theory

CZ2002 OBJECT ORIENTED DESIGN AND PROGRAMMING

Acad Unit: 3
Pre-requisite: CZ1007

Introduction to Object Orientated Programming; Classes and Objects; C++ Programming Language; Inheritance and polymorphism; Interface and implementation; Object Relationships; Object Collaboration; Designing for Reuse; Java Programming Language; Persistent Objects

CZ2003 COMPUTER GRAPHICS AND VISUALISATION

Acad Unit: 3
Pre-requisite: CZ1011

Introduction to computer graphics and foundation mathematics; Virtual Reality Modelling Language (VRML) and Extensible 3D (X3D); Geometric shapes; Visual appearance; Transformations and motions; Efficient rendering; Putting it all together

CZ2004 HUMAN COMPUTER INTERACTION

Academic Unit: .3
Pre-requisite: Nil

Introduction; Usability and application spaces; Guidelines for navigation, organization, attention and data entry; Prototyping and evaluating interface designs; Understanding humans, modelling users; Human-computer interfaces; Interaction and design analysis

CZ2005 OPERATING SYSTEMS

Acad Unit: 3
Pre-requisite: CZ1006, CZ1007

Overview of Operating Systems (OS); Processes and Threads; Process Scheduling; Process Synchronization; 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

CZ2006 SOFTWARE ENGINEERING

Acad Unit: 3
Pre-requisite: CZ2002 (can be taken concurrently)

Introduction to Software Engineering; Requirement Specification; Analysis; Project Management; Design; Implementation and Testing; Maintenance

CZ2007 INTRODUCTION TO DATABASES

Acad Unit: 3
Pre-requisite: CZ2001 (can be taken concurrently)

Introduction to Databases; Entity-Relationship Data Model; Relational Data Model; Functional Dependencies (FD) and Normalization; Relational Algebra; Querying Relational Databases; Introduction to Database Security; Semistructured Data and XML; Querying XML Data; Conclusion

THIRD YEAR

CZ3001 ADVANCED COMPUTER ARCHITECTURE

Acad Unit: 3
Pre-requisite: CZ1006

Introduction and Background: Review of basic computer architecture; Instruction Set Architecture Design; Micro-architecture Design; Memory Systems and I/O Design; Instruction-Level Parallelism; Data-Level Parallelism; Thread-Level Parallelism; Emerging Computing Trends

CZ3002 ADVANCED SOFTWARE ENGINEERING

Acad Unit: 3
Pre-requisite: CZ2006

Introduction; Software Quality Management; Project Management; Agile Methods; CMMI; Maintenance; Software Testing; Configuration Management

CZ3003 SOFTWARE SYSTEM ANALYSIS AND DESIGN

Acad Unit: 3
Pre-requisite: CZ2006 (can be taken concurrently)

Introduction; Requirement Engineering; Software Quality and Design Principles; Design Issues; Software Architecture Design; Design Quality Analysis and Evaluation; Software Construction; System Validation and Verification; System Deployment and Use

CZ3004 MULTIDISCIPLINARY DESIGN PROJECT (MDP)

Acad Unit: 4
Pre-requisite: At least Third Year Standing

The Multidisciplinary Design Project (MDP) is a group-based design project undertaken by a mixed group of students comprising of undergraduates from the CE, CS, BCG and BCE programmes. The project is practical-oriented and multi-disciplinary in nature, requiring system level integration of sub-systems developed by different team members.

The course project will be updated from year to year to remain interesting and relevant. Details of the current year's project will be made known to students at initial MDP briefing.
Microprocessors, Signals and Interfaces; Sensors and Communication; Software engineering; Data structures and Algorithms; Open-source frameworks; Human-computer interaction; System analysis and design

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.

CZ3005 ARTIFICIAL INTELLIGENCE

Acad Unit: 3
Pre-requisite: CZ1003, CZ2001

Human brain and Cognitive structure; Foundations of AI; Agent paradigm; Procedural Representation (Algorithmic); Symbolic Representation (Knowledge Engineering); AI in the Real World, Case studies of intelligent systems

CZ3006 NET CENTRIC COMPUTING

Acad Unit: 3
Pre-requisite: CZ1006, CZ2002

Introduction To Net-Centric Computing; The Physical Layer And Data Link Layer; The MAC Layer And Local Area Networks; The Network Layer And Internet IP Protocols; The Transport Layer And Internet TCP Protocols; Web Architecture And Protocols; Web Documentation Technologies; Client Application Programming Techniques; Server Application Programming Techniques

CZ3007 COMPILER TECHNIQUES

Acad Unit: 3
Pre-requisite: CZ2001, CZ2006

Introduction to Compilers; Lexical Analysis; Parsing; Semantic Analysis; Code Generation; Optimisation

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; Content Base Image retrieval

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; Image Edge Processing; Image Segmentation; Imaging Geometry and 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; Speech Production and Transcription; Audio Signal Analysis; Audio and Speech Signal Classification; Text to Speech Synthesis; Speaker Recognition/Verification

CE/CZ4011 PARALLEL COMPUTING

Acad Unit: 3
Pre-requisite: CZ/CE2001 & CZ/CE3001

Foundations & Theory; Distributed Memory Programming; Shared Memory Programming; Special E-Learning Topic**,** Load Balancing; Massively Parallel Programming; Cases Studies

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: CE/CZ1007 Data Structures, CE/CZ1011 Eng Maths

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: CE/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

Introduction of Pervasive Networks; Medium Access Control (MAC) for Wireless Networks; Routing in Mobile Ad Hoc Networks (MANETs); Mobility Management Services in Cellular Networks; Mobile Internet Protocol (IP)

CE/CZ4022 PERSONAL MOBILE NETWORKS

Acad Unit: 3
Pre-requisite: CE3005 or CZ3006

Fundamentals of Wireless Mobile Communications; 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

Security Threats and Security Goals; Mathematical Background; Secret-Key Cryptography; Public-Key Cryptography; Hash Functions and MACs; Key Management; Authentication Protocols; Key Establishment Protocols

CE/CZ4031 DATABASE SYSTEM PRINCIPLES

Acad Unit: 3
Pre-requisite: CE/CZ2001, CZ2007

Overview of Database Management Systems (DBMS); Storage of Relational Data; Indexing Techniques; Query Processing; Query Optimization; Failure Recovery; Transaction; Management and Concurrency Control; Advanced topics

CE/CZ4032 DATA ANALYTICS AND MINING

Acad Unit: 3
Pre-requisite: CE/CZ2001

Introduction of Data Analytics & Mining; Data Pre-processing; Data Analytics & Visualization; Cluster Pattern Analysis; Predictive Pattern Mining; Association Rule Mining; Anomaly Detection

CE/CZ4033 ADVANCED DATA MANAGEMENT

Acad Unit: 3
Pre-requisite: CE/CZ4031

Overview Of Data Management In The 21st Century; Data Warehousing; Column-Oriented DBMS; Graph Data Management; Spatial Data Management; In-Memory Data Management; Managing Time Series Data

CE/CZ4034 INFORMATION RETRIEVAL

Acad Unit: 3
Pre-requisite: CE/CZ2001

Introduction; Boolean Retrieval; Term Vocabulary and Posting; Dictionaries and Tolerant Retrieval; Index Construction and Compression; Scoring, Term Weighting, and Vector Space Model; IR Evaluation; Relevance Feedback and Query Expansion; Probabilistic IR and Language Model
Web Search; Link Analysis and Crawling

CE/CZ4041 MACHINE LEARNING

Acad Unit: 3
Pre-requisite: CE/CZ1007, CE/CZ1011

Overview of machine learning and its applications; Decision Theory and Bayes Models; Classifier Evaluation; Classification: Decision trees, artificial neural networks, linear and kernelized support vector machines, K-nearest neighbour classifiers, linear regression and its kernelized extension; Ensemble Learning; Clustering; Dimension Reduction; Density Estimation; Graphical Models; Applications

CE/CZ4042 NEURAL NETWORKS

Acad Unit: 3
Pre-requisite: CE/CZ1007, CE/CZ1011

Introduction To Neural Network; Basic Perceptron; Multi-Layer Perceptron Network; Performance Estimation And Model Selection; Kernel-Based Network; Convolution Neural Networks And Deep Learning; Self-Organizing Neural Network; Component Neural Networks; Associative Learning

CE/CZ4045 NATURAL LANGUAGE PROCESSING

Acad Unit: 3
Pre-requisite: CE/CZ2001

Introduction To Natural Language Processing; Spelling Checking; Word Prediction; Word Classes; Introduction To Classification Methods; Information Extraction; Formal Grammars; Syntactic Parsing; Computational Semantics

CE/CZ4046 INTELLIGENT AGENTS

Acad Unit: 3
Pre-requisite: CE/CZ1007, CE/CZ1011

Introduction to Intelligent Agents; Deductive Reasoning Agents; Practical Reasoning Agents; Reactive and Hybrid Architectures; Introduction to Multi-Agent Systems and Applications; Working Together; Multi-Agent Interaction; Allocating Scarce Resources – Auctions; Making Group Decisions; Forming Coalitions

CE/CZ4062 COMPUTER SECURITY (SYSTEM SECURITY)

Acad Unit: 3
Pre-requisite: CE/CZ2005

Introduction, Concepts, and Terminology; Identification and Entity Authentication; Access-Control; Security Models; Reference Monitors; Operating System Security; Software Security; Case Studies

CE/CZ4064 SECURITY MANAGEMENT

Acad Unit: 3
Pre-requisite: CE/CZ2006

Introduction; Information Security, Governance, and the Law; Model, Framework, and Approach; Organization and People; Risk Analysis and Assessments; Security Operations; Internal Control, Audit, and Security; Contingency Planning and Management

CE/CZ4065 DIGITAL FORENSICS

Acad Unit: 3
Pre-requisite: CE/CZ1011 or MH1812

Overview of forensic science; Anti-Forensics; Host Forensics; Information Hiding; Non-Standard Storage Mechanisms and Devices; Network Forensics

CE/CZ4071 NETWORK SCIENCE

Acad Unit: 3
Prerequisite: CE/CZ2001

Overview Of Network Science; Network Analysis Metrics; Properties Of Real-World Networks; Network Models; Network Querying; Network Analytics; Network Dynamics; Massive Graph/Network Engines

CE/CZ4072 BIG DATA MANAGEMENT

Acad Unit: 3
Prerequisite: CZ4031

Overview of Big data in the 21st century; Big data quality; Distributed data management; Data management in the cloud; Distributed data management on modern hardware; Programming models and declarative query languages; High speed big data streams; Big data visualization

CE/CZ4073 SPECIAL TOPIC: DATA SCIENCE FOR BUSINESS

Acad Unit: 3
Prerequisite: CE/CZ1007, CE/CZ1011

Introduction to Data Analytic Thinking; R in Data Science; Predictive Modelling; Data Preparation; Fitting a Model to Data; Similarity of Objects; Visualizing Model Performance; Evidence and Probabilities; Text Mining; Sentiment Analysis; Business Forecasting Models; Computational Intelligence in Business Forecasting; IT Projects for Business. IT and Business Strategy