

C. SCHOOL OF COMPUTING

1. Dean's Office

CP3106 Independent Project

Modular Credits: 4

Workload: Nil

Prerequisite(s): [(CS2102 or CS2102S) and CS2105 and read (CS3214 or CS3215)] or IS3102 or IS4102 or CS3201 or CS3281 or CS4201 or CS4203

Preclusion(s): Nil

Cross-listing(s): UIS3953R

The objective of this project module enables students to undertake substantial project work over a period of six months. Students may work individually or in groups on projects proposed by staff. They will have good opportunity to apply what they have learnt on practical problems, be it research-oriented or software development. At the end of the project, the students must submit a report to their respective supervisors describing in detail what they have accomplished.

CP3108A Independent Work

Modular Credits: 2

Workload: 0-0-0-5-0

Prerequisite(s): Nil

Preclusion(s): CS3108A

Cross-listing(s): Nil

This module allows students to explore their interest areas within the computing field and at the same time learn how to take initiative, plan and think critically, through the process of independent work. Students have to find a faculty mentor for the independent work and submit for approval a proposal outlining the learning objectives, schedule and evaluation criteria. The module will be graded by the faculty mentor and course coordinator as "Completed Satisfactory/Completed Unsatisfactory (CS/CU)". Credit will be given for CP3108A (2MC) depending on the workload proposed.

CP3108B Independent Work

Modular Credits: 4

Workload: 0-0-0-10-0

Prerequisite(s): Nil

Preclusion(s): CS3108B

Cross-listing(s): Nil

This module allows students to explore their interest areas within the computing field and at the same time learn how to take initiative, plan and think critically, through the process of doing independent work. Students have to find a faculty mentor for the independent work and submit for approval a proposal outlining the learning objectives, schedule and evaluation criteria. The module will be graded by the faculty mentor and course coordinator as "Completed Satisfactory/Completed Unsatisfactory (CS/CU)". Credit will be given for CS3108B (4MC) depending on the workload proposed.

CP3109 Overseas Exploratory Project

Modular Credits: 2

Workload: 0-0-0-2.5-2.5

Prerequisite(s): Nil

Preclusion(s): CS3109

Cross-listing(s): Nil

This module enables students to explore the operations of IT companies through educational visits to various sectors of IT industry. The visit enables students to develop global perspective of IT operations, and issues related to global IT services, management and engineering. The visit will be at least one week. Students are required to attend a pre-visit workshop (to attain basic technical knowledge required to appreciate the visit), organise the visit, and attend a post-visit workshop (to share and report their findings during the visit). They are also required to submit a report on their accomplishment of educational objectives from the trip. The module is evaluated as "Completed Satisfactory/ Completed Unsatisfactory (CS/CU)" based on the continual assessment and final

report.

CP3200 Internship

Modular Credits: 6

Workload: 0-0-0-15-0

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The IT industry and related businesses are developing rapidly. As such, students need to have an opportunity to expose themselves to the latest industry developments. This internship module requires students to work in a company for a period of three months. Their progress on projects will be monitored during attachment, and their performance will be graded as "Completed Satisfactory/Completed Unsatisfactory (CS/CU)" at the end of the attachment, based on the final project report. During the attachment, students are not expected to take other modules offered by the university.

CP3201 Industry Seminar

Modular Credits: 2

Workload: 2-0-0-2-1

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The information technology (IT) industry is in an ever-changing state of evolution and innovation. This module aims to acquaint students with the latest Information Technology (IT) innovation, practices, and developments. Prominent leaders and practitioners in the IT industry will be invited to impart their knowledge and insights into the latest IT trends and developments from various industry arenas, such as the finance, healthcare, consulting, manufacturing, and entertainment industries. Students' performance will be graded as "Completed Satisfactory/Completed Unsatisfactory (CS/CU)" at the end of the module based on the coursework.

CP3208 Undergraduate Research in Computing I

Modular Credits: 4

Workload: Nil

Prerequisite(s): [(CS2103 or CS2261) and (CS2305 or CS2305S)] or [(CS2103 and CS2309) or IS2103 or IS2150]

Preclusion(s): CS3208

Cross-listing(s): UIS3951R

The module (together with CS3209) is part of the UROP (Computing) project. The objective of this module, and the UROP (Computing) project in general, is to provide an opportunity for talented students to undertake a substantial research project under the supervision of faculty members of the School of Computing. Through this research collaboration, the student will get to experience first-hand the challenges and exhilaration of research, discovery and invention. This module should be followed by CS3209 to complete the UROP (Computing) project.

CP3209 Undergraduate Research in Computing II

Modular Credits: 4

Workload: Nil

Prerequisite(s): CS3208 or CP3208 or UIS3951R

Preclusion(s): CS3209

Cross-listing(s): UIS3952R

The module follows CP3208 and completes the requirements of the UROP (Computing) project. Please see CS3208 for description.

CP3880 Advanced Technology Attachment Programme

Modular Credits: 12

Workload: Nil

Prerequisite(s): [IS2101 and (CS2103 or IS2103 or IS2150)] and preferably completed [IS3102 or (CS3201 and CS3202) or (CS3281 and CS3282) or IS4102 or (CS4201 and CS4202) or (CS4203 and CS4204)]. Student Selection process will be enforced.

Preclusion(s): CS3880

Cross-listing(s): Nil

This module enables students to apply the computing knowledge they have assimilated in class to industrial projects through six-month attachments to companies/organisations. Students under attachment will be jointly guided by supervisors from both the companies/organisations and the school. Their progress on projects will be monitored during attachment, and their performance will be assessed on "Completed Satisfactory/ Completed Unsatisfactory (CS/CU) " basis at the end of the attachment, based on the interim and final project reports. During the attachment, students are not expected to take other modules offered by the university.

CP3881 Incubation Project

Modular Credits: 12

Workload: 0-0-0-0-15

Prerequisite(s): Business proposal must be accepted by Evaluation Committee of SoC Incubation Centre

Preclusion(s): CS3881

Cross-listing(s): Nil

This one-year module aims to nurture technopreneurship among students. It enables students to start up a company while studying in NUS. The start-ups will be placed in the SoC Incubation Centre, through which students receive assistance from the Centre in managing and operating their companies. Students are required to submit an interim report six months into their business, and a final report one year into their business. The reports will be assessed by the Incubation Centre Review Committee for students' ability in managing and operating their companies. The module is assessed on "Completed Satisfactory/Completed Unsatisfactory (CS/CU)" basis.

CP4101 B.Comp. Dissertation

Modular Credits: 12

Workload: 0-0-0-15-0

Prerequisite(s): Attain at least 70% of the MC requirement for the respective degree

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to enable students to work on an individual research project spanning two semesters, with approximately 400 hours of work. Students learn how to apply skills acquired in the classroom and also think of innovative ways of solving problems, and learn to work in a research environment. The project demonstrates a student's work ethic, initiative, determination, and ability to think independently. On completion of the project, the student has to submit a dissertation describing the project work, and give an oral presentation before a panel of examiners.

CP5010 Graduate Research Paper

Modular Credits: Nil

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The graduate research paper presentation is for evaluating the ability of the student to undertake a critical review of an existing research area. The student is expected to have the necessary background, and show competence in embarking on Ph.D. research. Students are expected to identify a promising research area.

The paper should be self-contained and provide a good overview of the research problems, initial exploration of the research area, and insight to the research problems, with preliminary study and proposals on the outstanding research issues. It should contain more findings than a survey paper.

CP6010 Doctoral Seminar

Modular Credits: Nil

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

A Ph.D. candidate will be required to give a Doctoral Seminar along with his/her Ph.D. Thesis Proposal. The seminar should include any research findings or work from published papers.

XFC4101 Integrated Honours Thesis

Modular Credits: 12

Workload: 0-0-0-15-0

Prerequisite(s): Attain at least 70% of the MC requirement for the respective degree

Preclusion(s): CP4101, CS4101, CS4349

Cross-listing(s): Nil

The objective of this module is to enable students to work on an individual integrated research project spanning over two semesters, with approximately 400 hours of workload. Students learn how to apply skills acquired in the classroom and also think of innovative ways of solving problems, while learning to work in a research environment. The project demonstrates a student's work ethic, initiative, determination, and ability to think independently. On completion of the project, the student has to submit a dissertation describing the project work, and give an oral presentation before a panel of examiners.

2. Department Of Computer Science

CS1010 Programming Methodology

Modular Credits: 4

Workload: 2-1-1-3-3

Prerequisite(s): Nil

Preclusion(s): CG1101, CS1010E, CS1101, CS1101C, CS1101S, CZ1102, IT1002. Engineering and Science students who require this module for their majors/minors are not allowed to read it as ULR-Breadth.

Cross-listing(s): Nil

This module introduces the fundamental concepts of problem solving by computing and programming using an imperative programming language. It is the first and foremost introductory course to computing. It is also the first part of a three-part series on introductory programming and problem solving by computing, which also includes CS1020 and CS2010. Topics covered include problem solving by computing, writing pseudo-codes, basic problem formulation and problem solving, program development, coding, testing and debugging, fundamental programming constructs (variables, types, expressions, assignments, functions, control structures, etc.), fundamental data structures: arrays, strings and structures, simple file processing, and basic recursion. This module is appropriate for SoC and FoS students.

CS1010E Programming Methodology

Modular Credits: 4

Workload: 2-1-1-3-3

Prerequisite(s): Nil

Preclusion(s): CG1101, CS1010, CS1101, CS1101C, CS1101S, CZ1102, IT1002

Cross-listing(s): Nil

This module introduces the fundamental concepts of problem solving by computing and programming using an imperative programming language. It is the first and foremost introductory course to computing. It is also the first part of a three-part series on introductory programming and problem solving by computing, which also includes CS1020E and CS2010. Topics covered include problem solving by computing, writing pseudo-codes, basic problem formulation and problem solving, program development, coding, testing and debugging, fundamental programming constructs (variables, types, expressions, assignments, functions, control structures, etc.), fundamental data structures: arrays, strings and structures, simple file processing, and basic recursion. This module is appropriate for FoE students.

CS1101S Programming Methodology

Modular Credits: 5

Workload: 3-2-1-3-3

Prerequisite(s): No programming or computer science experience is required. GCE 'A' Level Mathematics or H2 Mathematics or MA1301

Preclusion(s): CG1101, CS1010, CS1010E, CS1101, CS1101C, CZ1102, IT1002, Engineering students

Cross-listing(s): Nil

This module introduces the concepts of programming from a functional perspective, and is perceived as the first and foremost introductory course to computing. This series is characterised by the use of a minimalist syntax of functional languages that enables an emphasis on fundamental programming issues. Topics covered include: overview of programming languages and compilation process, procedural abstraction, recursion, data abstraction, algorithmic strategies, higher-order functions, state mutation, evaluation strategies, debugging and testing. Module activities include lectures, recitation, tutorial and laboratory exercises.

CS1020 Data Structures and Algorithms I

Modular Credits 4

Workload: 2-1-1-3-3

Prerequisite(s): CS1010 or its equivalent

Preclusion(s): CG1102, CG1103, CS1020E, CS1102, CS1102C, CS1102S, CS2020

Cross-listing(s): Nil

This module is the second part of a three-part series on introductory programming and problem solving by computing. It continues the introduction that begins in CS1010, and emphasises object-oriented programming with application to simple data structures. Topics covered include object-oriented problem modelling with concepts of objects, classes and methods, object-oriented problem formulation and problem solving, data structure implementation strategies, abstraction and encapsulation of data structures, object-oriented programming constructs, use of APIs and class libraries, exception handling, lists, linked lists, stacks, queues, hash tables and their algorithmic design, various forms of sorting and searching methods, recursive algorithms, and Big-O notation. This module is appropriate for SoC and FoS students.

CS1020E Data Structures and Algorithms I

Modular Credits 4

Workload: 2-1-1-3-3

Prerequisite(s): CS1010E

Preclusion(s): CG1102, CG1103, CS1020, CS1102, CS1102C, CS1102S, CS2020

Cross-listing(s): Nil

This module is the second part of a three-part series on introductory programming and problem solving by computing. It continues the introduction that begins in CS1010E, and emphasises object-oriented programming with application to simple data structures. Topics covered include object-oriented problem modelling with concepts of objects, classes and methods, object-oriented problem formulation and problem solving, data structure implementation strategies, abstraction and encapsulation of data structures, object-oriented programming constructs, use of APIs and class libraries, exception handling, lists, linked lists, stacks, queues, hash tables and their algorithmic design, various forms of sorting and searching methods, recursive algorithms, and Big-O notation. This module is appropriate for FoE students.

CS1231 Discrete Structures

Modular Credits: 4

Workload: 3-1-0-3-3

Prerequisite(s): GCE 'A' Level Mathematics or H2 Mathematics or MA1301

Preclusion(s): MA1100

Cross-listing(s): Nil

This module introduces mathematical tools required in the study of computer science. Topics include:

- (i) Logic and proof techniques: propositions, conditionals, quantifications.
- (ii) Relations and Functions: Equivalence relations and partitions, partially ordered sets, well-Ordering Principle, function equality, Boolean/identity/inverse functions, bijection.
- (iii) Mathematical formulation of data models (linear model, trees, and graphs).
- (iv) Counting and Combinatoric: Pigeonhole Principle, Inclusion-Exclusion Principle, Number of relations on a set, number of injections from one finite set to another, Diagonalisation proof: An infinite countable set has an uncountable power set; Algorithmic proof: An infinite set has a countably infinite subset. Subsets of countable sets are countable.

CS1280 Java to C++

Modular Credits: 2

Workload: 2-0-1-0-3

Prerequisite(s): CS1020 or CS2020

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims to train students who have learned data structures and algorithms in Java to programme in C++. Basic constructs common in the two languages will not be covered (e.g. if-else, loops etc). Topics covered include: Objects and classes in C++, fundamental data structures: arrays, strings, vectors, I/O, exception handling, sub-classing, inheritance, template function, template class, use of STL, and defining operator. Assessment of students in this module will be on either Satisfactory/Unsatisfactory (S/U) or Completed Satisfactory/Completed Unsatisfactory (CS/CU) basis depending on students' matriculation year. Students matriculated in AY2007/08 and after will be assessed on CS/CU basis. The duration of the course is six weeks, opening at beginning of semesters.

CS1281 C++ to Java

Modular Credits: 2

Workload: 2-0-1-0-3

Prerequisite(s): CS1020E

Preclusion(s): Nil

Cross-listing(s): Nil

The module aims to train students who have learned data structures and algorithms in C++ to programme in Java. Basic constructs common in the two languages will not be covered (e.g. if-else, loops etc). Topics covered include: Objects and classes in Java, fundamental data structures: arrays, strings, I/O, exception handling, use of APIs and class libraries, sub-classing, inheritance, abstract and interface class, new design concept using generic Java approach. Assessment of students in this module will be on either Satisfactory/Unsatisfactory (S/U) or Completed Satisfactory/Completed Unsatisfactory (CS/CU) basis depending on students' matriculation year. Students matriculated in AY2007/08 and after will be assessed on CS/CU basis. The duration of the course is six weeks, opening at beginning of semesters.

CS2010 Data Structures and Algorithms II

Modular Credits: 4

Workload: 2-1-1-3-3

Prerequisite(s): CS1020 or CS1020E or CG1103

Preclusion(s): CG1102, CS1102, CS1102C, CS1102S, CS2020

Cross-listing(s): Nil

This module is the third part of a three-part series on introductory programming and problem solving by computing. It continues the introduction in CS1010 and CS1020, and emphasises object-oriented programming with application to complex data structures. Topics covered include trees, binary search trees, order property, prefix/infix/postfix expressions, heaps, priority queues, graphs and their algorithmic design, recursive algorithms, problem formulation and problem solving with applications of complex data structures, data structure design principles and implementation strategies, and algorithm analysis. Advanced data structures such as B-trees and AVL trees are also covered.

CS2020 Data Structures and Algorithms Accelerated

Modular Credits: 6

Workload: 4-2-2-4-3

Prerequisite(s): Obtain a grade of at least A- in either CS1010 or CS1101S

Preclusion(s): CG1102, CG1103, CS1020, CS1020E, CS2010, CS1102, CS1102C, CS1102S

Cross-listing(s): Nil

This module is an accelerated version that combines CS1020 and CS2010. It continues the introduction in CS1010, and emphasises object-oriented programming with application to data structures. Topics covered include object-oriented problem

modelling with concepts of objects, classes and methods, object-oriented problem formulation and problem solving, data structure design principles and implementation strategies, abstraction and encapsulation of data structures, object-oriented programming constructs, use of APIs and class libraries, exception handling, lists, linked lists, stacks, queues, hash tables, trees, graphs, and their algorithmic design, various forms of sorting and searching methods, recursive algorithms, and algorithm analysis.

CS2100 Computer Organisation

Modular Credits: 4

Workload: 3-1-1-3-2

Prerequisite(s): CS1010 or its equivalent

Preclusion(s): CS1104 and students from the Department of ECE.

Cross-listing(s): Nil

The objective of this module is to familiarise students with the fundamentals of computing devices. Through this module, students will understand the basics of data representation, and how the various parts of a computer work, separately and with each other. This allows students to understand the issues in computing devices, and how these issues affect the implementation of solutions. Topics covered include data representation systems, combinational and sequential circuit design techniques, assembly language, processor execution cycles, pipelining, memory hierarchy and input/output systems.

CS2101 Effective Communication for Computing Professionals

Modular Credits: 4

Workload: 0-4-0-4-2

Prerequisite(s): Students have to complete ES1000 and/or ES1102 (if required to take the module/s) before reading this module.

Co-requisite(s): Students have to read CS2103T Software Engineering at the same time as this module.

Preclusion(s): CG1413, EG1413, IS2101, ES2002, ES2007S and ES2007D

Cross-listing(s): Nil

This module aims to equip students with the skills needed to communicate technical information to technical and non-technical audiences, and to create comprehensible software documentation. A student-centric approach will be adopted to encourage independent and collaborative learning while engaging students in team-based projects. Students will learn interpersonal and intercultural communication skills as well as hone their oral and written communication skills. Assessment modes include a variety of oral and written communication tasks such as reports, software guides, oral presentations, software demonstrations and project blogs.

CS2102 Database Systems

Modular Credits: 4

Workload: 2-1.5-0.5-3-3

Prerequisite(s): (CS1020 or its equivalent) and (CS1231 or MA1100)

Preclusion(s): CS2102S, IT2002

Cross-listing(s): Nil

The aim of this module is to introduce the fundamental concepts and techniques necessary for the understanding and practice of design and implementation of database, applications, and the management of data with relational database management systems. The module covers practical and theoretical aspects of design with entity-relationship model, theory of functional dependencies and normalisation by decomposition in second, third and Boyce-Codd normal forms. The module covers practical and theoretical aspects of programming with SQL data definition and manipulation sublanguages, relational tuple calculus, relational domain calculus and relational algebra.

CS2103 Software Engineering

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS1020 or its equivalent

Preclusion(s): CS2103T, Science students majoring in Computational Finance are not allowed to read it as ULR-Breadth. EEE and CPE students can only take this module as a technical elective to satisfy the programme requirements or UEM but not ULR-Breadth.

Cross-listing(s): Nil

This module introduces the necessary conceptual and analytical tools for systematic and rigorous development of software systems. It covers four main areas of software development, namely object-oriented system analysis, object-oriented system modelling and design, implementation, and testing, with emphasis on system modelling and design and implementation of software modules that work cooperatively to fulfill the requirements of the system. Tools and techniques for software development, such as Universal Modelling Language (UML), program specification, and testing methods, will be taught. Major software engineering issues such as modularisation criteria, program correctness, and software quality will also be covered.

CS2103T Software Engineering

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): For SoC students only. CS1020 or its equivalent,

Co-requisite(s): Students have to read CS2101 Effective Communication for Computing Professionals at the same time as this

module.

Preclusion(s): CS2103, IS2101 or its equivalent.

Cross-listing(s): Nil

This module introduces the necessary conceptual and analytical tools for systematic and rigorous development of software systems. It covers four main areas of software development, namely object-oriented system analysis, object-oriented system modelling and design, implementation, and testing, with emphasis on system modelling, design and implementation of software modules that work cooperatively to fulfill the system's requirements. Tools for software development, such as Universal Modelling Language, program specification, and testing methods will be taught. Software engineering issues such as modularisation criteria, program correctness, and software quality will be covered. This module must be taken together with CS2101 Effective Communication for Technologists.

CS2104 Programming Language Concepts

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): CS1020 or its equivalent

Preclusion(s): Nil

Cross-listing(s): Nil

This module introduces the concepts that serve as a basis for hundreds of programming languages. It aims to provide the students with a basic understanding and appreciation of the various essential programming-languages constructs, programming paradigms, evaluation criteria and language implementation issues. The module covers concepts from imperative, object-oriented, functional, logic, constraints, and concurrent programming. These concepts are illustrated by examples from varieties of languages such as Pascal, C, Java, Smalltalk, Scheme, Haskell, Prolog. The module also introduces various implementation issues, such as pseudo-code interpretation, static and dynamic semantics, abstract machine, type inferencing, etc.

CS2105 Introduction to Computer Networks

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): (CS1020 or CS1020E or CS1102 or CS1102C or CS1102S) and (CS1104 or CS2100)

Preclusion(s): IT2001, EE3204/E, EE4210. EEE & CPE students are not allowed to take this module.

Cross-listing(s): Nil

This course aims to provide a broad introduction to computer networks and some appreciations of network application programming. It covers a range of topics including basic data communication and computer network concepts, protocols, network computing concepts and principles, network applications development and network security. The emphasis of teaching is on the working principles and application of computer networks. As an integral part of the course, tutorials and practical assignments enforcing learning will also be given. These assignments provide an early exposure to network application programming and students should be able to complete them by using personal computers and the school's network facilities.

CS2106 Introduction to Operating Systems

Modular Credits: 4

Workload: 2-1-1-0-4

Prerequisite(s): CS2100 or EE2007 or EE2024

Preclusion(s): CG2271 or EE4214. CEG students are not allowed to take this module.

Cross-listing(s): Nil

This module introduces the basic concepts in operating systems and links it with contemporary operating systems (eg. Unix/Linux and Windows). It focuses on OS structuring and architecture, processes, memory management, concurrency and file systems. Topics include kernel architecture, system calls, interrupts, models of processes, process abstraction and services, scheduling, review of physical memory and memory management hardware, kernel memory management, virtual memory and paging, caches, working set, deadlock, mutual exclusion, synchronisation mechanisms, data and metadata in file systems, directories and structure, file system abstraction and operations. Examples will be discussed from contemporary operating systems such as Unix/Linux and/or Windows.

CS2107 Introduction to Information and System Security

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS1010 or its equivalent)

Preclusion(s): Nil

Cross-listing(s): Nil

This module serves as an introductory module on information and computer system security. It illustrates the fundamentals of how systems fail due to malicious activities and how they can be protected. The module also places emphasis on the practices of secure programming and implementation. Topics covered include classical/historical ciphers, introduction to modern ciphers and cryptosystems, ethical, legal and organisational aspects, classic examples of direct attacks on computer systems such as input validation vulnerability, examples of other forms of attack such as social engineering/phishing attacks, and the practice of secure programming.

CS2220 Introduction to Computational Biology

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): CS1020 or its equivalent. LSM1102 highly recommended.

Preclusion(s): Nil

Cross-listing(s): Nil

There are three aims in this course. First, the course provides, from programmers' viewpoint, an overview of common computational techniques used in the field of bioinformatics, including similarity operations, clustering and classification techniques, and techniques in gene recognition. Second, the basic theory behind these techniques will be covered. Last, but not least, the course demonstrates the role of bioinformaticians as a bridge between the field of computer science and biology, and prepares students for advanced computer-science topics relevant to bioinformatics.

CS2271 Embedded Systems

Modular Credits: 4

Workload: 2-1-2-3-3

Prerequisite(s): (CS1020 or CS1020E or CS1102 or CS1102C or CS1102S) and (CS1104 or CS2100) (for students admitted on or before AY2002/03) or EE2006 (for students admitted after AY2002/03), and students must have programming knowledge in C or have passed CS2281 Programming in UNIX.

Preclusion(s): CG2271

Cross-listing(s): Nil

The explosive growth of transistor density has moved the centre of gravity of computing from personal computers to numerous embedded computers hidden away inside our everyday electronic products. Designing embedded computing systems is unique in the sense that the traditional borderline between hardware and software vanishes here. This module aims to provide a broad overview of the techniques and challenges involved in designing embedded systems. Topics include: FPGAs, high-level programming of FPGAs, DSP, and embedded microprocessor, embedded software development, real-time operating systems, and hardware/software codesign.

CS2281 Programming in UNIX

Modular Credits: 3

Workload: 2-0-1-3-2

Prerequisite(s): CS1020 or its equivalent

Preclusion(s): CS1101C or CS1102C

Cross-listing(s): Nil

This module aims to train students to be proficient in dealing with UNIX systems. Topics include: C programming: Variables, types, operators, expressions, control flow, functions, function arguments, recursion, pointers, address arithmetic, arrays, structures, standard input/output. Unix system interface: file/directory manipulation, system data files, Unix processes, process control, signals, inter-process communication (pipe, FIFO), terminal I/O. Unix tools: shell programming (Bourne shell), programming tools (Xemacs, gcc, make, ddd debugger), regular expressions and text utilities (grep, awk, sed).

CS2309 CS Research Methodology

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): (CS2010 or its equivalent) and (CS1231 or MA1100).

Preclusion(s): CS2305S

Cross-listing(s): Nil

In this module, students will learn thinking and problem-solving skills, read and present research papers, write research reports, and do a substantial project within the computing area. Topics include logical and deductive reasoning, doing proofs, inductive reasoning and statistical analysis, fallacies and psychological traps, survey skills, abstraction and modelling, problem-solving heuristics, creative thinking, decision making, and reading of research papers from various computing sub-areas. In addition, students will also do an in-depth study of a computing area through independent study and project work.

CS3103 Computer Networks and Protocols

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): (CS2105 or EE3204/E) and co-read CS3103L

Preclusion(s): EE4210.

Cross-listing(s): Nil

This module focuses mainly on TCP/IP protocol stack and discusses the design of various protocols in the stack, their semantics and interoperability issues including concepts behind designing such protocols. The Internet technology protocols like ARP, ICMP, IP, DHCP, DNS, TCP, UDP, Routing protocols like OSPF and new IP protocol version IPv6 are discussed in detail. The dynamics of the TCP protocol is discussed in detail including congestion control and its behaviour in the wireless and mobile network environment. The client server communication paradigm is introduced and students are given the opportunity to develop distributed application using sockets and/or RPC/XML.

CS3103L Computer Networks Laboratory

Modular Credits: 2
Workload: 0-0-2-0-3
Prerequisite(s): Co-read CS3103
Preclusion(s): Nil
Cross-listing(s): Nil

The objective of the module is to augment the concepts learnt in the area of networking through hands on experiments, thus maximising the educational experience of students. It provides an opportunity for students to interconnect LANs in the laboratory using switches, routers, terminal servers etc., and conduct various experiments relating to TCP/IP protocol stack. Students perform hands-on experiments in subnetting, dial-up service, DHCP, DNS, Multicast, RIP, OSPF, router based firewall, TCP handshaking and congestion mechanism.

CS3201 Software Engineering Project I

Modular Credits: 4
Workload: 1-1-0-5-3
Prerequisite(s): CS2103 and (CS2301 or IS2101)
Preclusion(s): CS3215
Cross-listing(s): UIS3955R

This module is the first part of a two-part series on the practice of software engineering in Software Development Life Cycle (SDLC). These two modules together provide the students with hands-on experience in working in project groups through a complete SDLC to develop a well-designed, well-tested, large-scale software system. This first part focuses on applying best software engineering practices on the analysis and design of software system. The students will practise analysis of user's needs, formulation of computing requirements to meet the user's needs, modelling and design of the computer systems according to the requirements, and evaluation of the design.

CS3202 Software Engineering Project II

Modular Credits: 4
Workload: 1-1-0-5-3
Prerequisite(s): CS3201
Preclusion(s): CS3215
Cross-listing(s): UIS3956R

This module is the second part of a two-part series on the practice of software engineering in Software Development Life Cycle (SDLC). These two modules together provide the students with hands-on experience in working in project groups through a complete SDLC to develop a well-tested, large-scale software system. This second part focuses on applying best software engineering practices on the implementation and testing of the software system. The students will practice efficient implementation of software components, system integration, software version control, and rigorous testing.

CS3210 Parallel Computing

Modular Credits: 4
Workload: 2-1-0-3-4
Prerequisites: CS2100
Preclusion(s): Nil
Cross-listing(s): Nil

The aim of this module is to provide an introduction to the field of parallel computing with hands-on parallel programming experience on real parallel machines. The module is divided into four parts: parallel computation models and parallelism, parallel architectures, parallel algorithm design and programming, and new parallel computing models. Topics includes: theory of parallelism and models; shared-memory architectures; distributed-memory architectures; data parallel architectures; interconnection networks, topologies and basic of communication operations; principles of parallel algorithm design; performance and scalability of parallel programs, overview of new parallel computing models such as grid, cloud, GPGPU.

CS3211 Parallel and Concurrent Programming

Modular Credits: 4
Workload: 2-1-0-3-3
Prerequisite(s): CS2106 or CG2271
Preclusion(s): Nil
Cross-listing(s): Nil

A concurrent system consists of a set of processes that executes simultaneously and that may collaborate by communicating and synchronising with one another. Examples of concurrent systems are parallel programmes that describe sets of collaborating processes. This module introduces the design, development and debugging of parallel programmes. It will build on the concurrency concepts gained from the Operating Systems module. It covers concepts and modelling tools for specifying and reasoning (about the properties of) concurrent systems and parallel programmes. It also covers principles of performance analysis, asynchronous and asynchronous parallel programming, and engineering concurrent systems and parallel programmes.

CS3212 Programming Languages

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): CS2010 or its equivalent

Preclusion(s): Nil

Cross-listing(s): Nil

This module provides the students with theoretical knowledge and practical skill in the design and implementation of programming languages. It discusses the theory behind the fundamental programming paradigms (imperative, functional, logic, and object-oriented) and behind basic programming language concepts such as binding, scope, parameter-passing mechanisms and types. It introduces the language processing techniques of interpretation and compilation. A discussion of virtual machines highlights that programme execution almost always uses both, often in a multi-level hierarchical architecture. The course covers automatic memory management as a feature of programming systems and its implementation.

CS3213 Software Systems Design

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisites: CS2103

Preclusion(s): Nil

Cross-listing(s): Nil

Software design is a life cycle activity in which software requirements are analyzed to produce a description of the software's internal structure that serves as the basis for its construction. Software design consists of two activities that fit between software requirements analysis and software construction: software architectural design and software detailed design. Typical outcomes are the software architecture and the interfaces between components, specified in a design document. This module covers both levels of design and aims to equip students with the knowledge and skills for generating design documents and evaluating design alternatives in an iterative software development process.

CS3216 Software Development on Evolving Platforms

Modular Credits: 5

Workload: 2-1-0-8-2

Prerequisites: CS3217. Students without the prerequisite (in particular non-computer science students) but with strong design knowledge and skills can still take this course with the approval of the instructor.

Preclusion(s): Nil

Cross-listing(s): Nil

This module is a follow-up of CS3217 on the practice of software engineering on modern application platforms such as mobile devices, the Web and cloud systems. Students will work in small project teams to develop well-tested, production-quality software. This module focuses on the design and rapid iterative development of real-world applications. Students will analyse user needs, design and develop applications that meet user needs, and address user feedback of the applications. Students will also learn rapid development using APIs, Open Source tools and other modern tools, and deployment of the applications in the Web or cloud system.

CS3217 Software Engineering on Modern Application Platforms

Modular Credits: 5

Workload: 1-1-0-9-2

Prerequisites: CS2103 or with special approval from instructor. Students will submit personal statements to apply for a place in the course instead of bidding through the CORS system.

Preclusion(s): Nil

Cross-listing(s): Nil

This module introduces students to the practice of software engineering on modern application platforms such as mobile devices, the Web and cloud systems. Students will work in small project teams to develop well-tested, production-quality software. This module focuses on building core software engineering skills and competencies in programming modern application platforms. It also trains students to work well in project teams. Students will be assessed on both their individual programming competencies and their software engineering skills in final team project.

CS3220 Computer Architecture

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): CS2106

Preclusion(s): EEE & CPE students are not allowed to take this module.

Cross-listing(s): Nil

The objective of this module is concerned with design techniques involving the use of parallelism to improve the performance of computer systems. The module is divided into three parts. Part I considers the fundamental methods to improve the performance of single processor systems. Topics include the design principle of instruction set, memory hierarchy, pipeline design techniques, RISC and vector computer. In Part II, multi-processor systems using shared memory are examined in detail, and Part III, multi-processor

systems that do not use shared memory are examined.

CS3221 Operating Systems Design and Pragmatics

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): (CS1020 or its equivalent) and CS2106

Preclusion(s): Nil

Cross-listing(s): Nil

This module builds upon the conceptual foundation formed in CS2106 and extends it to the study of real-life operating systems. The focus is to understand how actual operating systems work, including the pragmatics, system architecture and design and implementation. Details will be drawn from contemporary operating systems such as Unix/Linux and Windows. Topics include kernel architecture and interfaces, computer architecture issues, process APIs and implementation, threads, scheduling, physical and kernel memory management, virtual memory, synchronisation and interprocess communication mechanisms, multi-processor issues, device characteristics and management, file system implementation, memory mapped files, special purpose file systems.

CS3223 Database Systems Implementation

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): (CS2010 or its equivalent) and (CS2102 or CS2102S)

Preclusion(s): Nil

Cross-listing(s): Nil

This module provides an in-depth study of the concepts and implementation issues related to database management systems. It first covers the physical implementation of relational data model, which includes storage management, access methods, query processing, and optimisation. Then it covers issues and techniques dealing with multi-user application environments, namely, transactions, con-currency control and recovery. The third part covers object-database systems that are useful extensions of relational databases to deal with complex data types. The last part covers database technologies required for modern decision support systems, including data warehousing, data mining and knowledge discovery, and online analytical processing.

CS3225 Combinatorial Methods in Bioinformatics

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): (CS2010 or its equivalent) and (CS2220 or LSM2104)

Preclusion(s): Nil

Cross-listing(s): Nil

After the complete sequencing of a number of genomes, we are at the stage of understanding the mystery of our body, that is, we need to understand the information encoded in the genome, and its relationship with RNA and protein. This aim of this module is to cover algorithms related to this stage. In the module, we will cover the algorithms related to genome annotation, motif identification, proteomics, population genetics, microarray, etc.

CS3230 Design and Analysis of Algorithms

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): (CS2010 or its equivalent) and (CS1231 or MA1100)

Preclusion(s): EEE and CPE students can only take this module as a technical elective to satisfy the programme requirements or UEM but not CFM/ULR-Breadth.

Cross-listing(s): Nil

This module introduces different techniques of designing and analysing algorithms. Students will learn about the framework for algorithm analysis, for example, lower bound arguments, average case analysis, and the theory of NP-completeness. In addition, students are exposed to various algorithm design paradigms. The module serves two purposes: to improve the students' ability to design algorithms in different areas, and to prepare students for the study of more advanced algorithms. The module covers lower and upper bounds, recurrences, basic algorithm paradigms (such as prune-and-search, dynamic programming, branch-and-bound, graph traversal, and randomised approaches), amortised analysis, NP-completeness, and some selected advanced topics.

CS3233 Competitive Programming

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): At least grade 'A-' in (CS2010 or its equivalent) or special permission

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims to prepare students in competitive problem solving. It covers techniques for attacking and solving challenging computational problems. Fundamental algorithmic solving techniques covered include divide and conquer, greedy, dynamic programming, backtracking, and branch and bound. Domain specific techniques like number theory, computational geometry, string processing and graph theoretic will also be covered. Advanced AI search techniques like iterative deepening, A* and heuristic

search will be included. The module also covers algorithmic and programming language toolkits used in problem solving supported by the solution of representative or well-known problems in the various algorithmic paradigms.

CS3234 Logic and Formal Systems

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): CS1231 or MA1100; Programming experience is preferred.

Preclusion(s): Nil

Cross-listing(s): Nil

This module focuses on the deductive and algorithmic aspects of both classical and non-classical logics. It introduces logic as a means for specifying, verifying and reasoning about computer programmes. It emphasizes, in contrast to other similar logic courses, how logic can be used to represent computational problems, how these representations can be proven correct and how they can be executed on a computer. Topics covered include classical logic theories, logic programming, modal logic, and an introduction to non-standard logics. Treatments of predicate calculus and temporal logic are fully covered with emphasis on their specification, verification, deductive and algorithmic aspects.

CS3235 Computer Security

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): (CS2105 or EE3204) and (CS2106 or CG2271) and CS2107

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to provide a broad understanding of computer security with some in-depth discussions on selected topics in system and network security. This module covers the following topics: intrusion detection, DNS security, electronic mail security, authentication, access control, buffer overflow, memory and stack protection, selected topics in application security, for instance, web security, and well-known attacks.

CS3240 Human-Computer Interaction

Modular Credits: 4

Workload: 2-0.5-1-5-2.5

Prerequisite(s): (CS1010 or its equivalent) or IT1002

Preclusion(s): Nil

Cross-listing(s): Nil

This course is intended for students in computing disciplines whose work focuses on human-computer interaction issues in the design of software systems. The course stresses the importance of user-centred design and usability in the development of software applications and systems. Students will be taken through the analysis, design, development, and evaluation of human-computer interaction methods for software systems. They will acquire hands-on design skills through interaction design project. The course also covers HCI design principles and emphasizes the importance of contextual, organisational, and social factors in system design.

CS3241 Computer Graphics

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): CS1020 or its equivalent

Preclusion(s): EEE and CPE students can only take this module as a technical elective to satisfy the programme requirements or UEM but not CFM/ULR-Breadth.

Cross-listing(s): Nil

This module teaches some graphics hardware devices, reviews the mathematics related to the understanding of such devices, and discusses the fundamental areas of computer graphics. After completing the course, students are expected to understand the basic computer graphics terminology and concepts, and to be able to design and implement simple 2D and 3D interactive computer graphics related programmes. As an enrichment part of the course, students are introduced to the state-of-the-art development in computer graphics by viewing interesting video clips, and experimenting with demo programmes made available in the course web.

CS3243 Introduction to Artificial Intelligence

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): (CS2010 or its equivalent) and (CS1231 or MA1100).

Preclusion(s): EEE and CPE students can only take this module as a technical elective to satisfy the programme requirements or UEM but not CFM/ULR-Breadth.

Cross-listing(s): Nil

The module introduces the basic concepts in search and knowledge representation, as well as to a number of sub-areas of artificial intelligence. It focuses on covering the essential concepts in AI. The module covers Turing test, blind search, iterative deepening, production systems, heuristic search, A* algorithm, minimax and alpha-beta procedures, predicate and first-order logic, resolution refutation, non-monotonic reasoning, assumption-based truth maintenance systems, inheritance hierarchies, the frame problem,

certainly factors, Bayes' rule, frames and semantic nets, planning, learning, natural language, vision, and expert systems and LISP.

CS3244 Machine Learning

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): (CS2010 or its equivalent) and (ST1232 or ST2131 or ST2132)

Preclusion(s): Nil

Cross-listing(s): Nil

This module introduces basic concepts and algorithms in machine learning and neural networks. The main reason for studying computational learning is to make better use of powerful computers to extract knowledge (or regularities) from the raw data. The ultimate objective is to build self-learning systems to relieve humans from some programming tasks. At the end of the course, students are expected to be familiar with the theories and paradigms of computational learning, and capable of implementing basic learning systems.

CS3245 Information Retrieval

Modular Credits: 4

Workload: 2-1-0-5-2

Prerequisite(s): CS2010 or its equivalent

Preclusion(s): Nil

Cross-listing(s): Nil

This module discusses the basic concepts and methods of information retrieval including capturing, representing, storing, organising, and retrieving unstructured or loosely structured information. The most well-known aspect of information retrieval is document retrieval: the process of indexing and retrieving text documents. However, the field of information retrieval includes almost any type of unstructured or semi-structured data, including newswire stories, transcribed speech, email, blogs, images, or video. Therefore, information retrieval is a critical aspect of Web search engines. This module also serves as the foundation for subsequent modules on the understanding, processing and retrieval of particular web media.

CS3246 Hypermedia and World Wide Web

Modular Credits: 4

Workload: 2-1-0-5-2

Prerequisite(s): CS1020 or its equivalent

Preclusion(s): CS4341

Cross-listing(s): Nil

This module introduces the theory, technologies and applications of hypermedia, and its relation to the World Wide Web (WWW). The module is divided into three parts. The first part covers the content aspects of digital media technologies including characteristics, mathematical foundation, encoding and processing of text, audio, image and video, and standards in digital media such as MP3, JPEG and MPEG. The second part covers the essence of hypermedia technologies, including the design and structure of hypermedia system, hypermedia models, WWW, XML and Semantic Web. The third part covers the application of hypermedia technologies in retrieval, mobile and Web 2.0 applications.

CS3248 Design of Interactive Systems

Modular Credits: 4

Workload: 2-1-1-4-2

Prerequisite(s): SoC and other students: CS3249 and CS3240. For FASS students: NM2217.

Preclusion(s): Nil

Cross-listing(s): Nil

The module focuses on the design of interactive computing systems that enhance and support the cognitive and creative processes of their users. It emphasizes the creative design of innovative solutions. Throughout the course, students will learn the design principles and interactive solutions in application domains such as safety, security, surveillance, biomedical informatics and healthcare, or in specific technological areas such as interactive and digital media, social computing, tangible user interface, human robot interaction, and mobile HCI. They will put into practice various design principles through small-scaled design assignments. They will also learn to use user-centred evaluation methods for evaluating the design.

CS3249 Elements of User Interface Design

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): CS1020 or its equivalent

Preclusion(s): Nil

Cross-listing(s): Nil

This module introduces the fundamental concepts in the design and implementation of user interfaces. Emphasis will be placed on the design and implementation of user interface in general, including graphical user interface. After taking this module, students will acquire practical knowledge and skills in the design and implementation of general user interfaces. Topics covered include style of user interface, interface devices, design guidelines, implementation tools, design elements and issues, and information visualisation.

CS3271 Software Engineering for Reactive Systems

Modular Credits: 4

Workload: 2-1-2-3-2

Prerequisite(s): CG2271 or CS2271

Preclusion(s): EE3304, EE/CPE students

Cross-listing(s): Nil

Reactive systems are real-time systems that continuously interact with the environment. This module introduces students to the software engineering principles for designing systems such as controllers and signal processors that are used in a wide variety of settings, including industrial plants, chemical reactors, flight and automotive controllers, and robots. Topics to be covered will include fundamentals of control software, programming languages for real-time controllers, and verification and optimisation of software for digital control systems. Apart from a variety of programming assignments, this course will also introduce students to some relevant research topics in this area.

CS3281 Thematic Systems Project I

Modular Credits: 4

Workload: 2-2-0-4-2

Prerequisite(s): CS2103 and have passed at least one primary module in a CS focus area. Student selection process will be enforced.

Preclusion(s): Nil

Cross-listing(s): Nil

This module is the first of a two-part series on the development of large-scaled computer systems to solve real-world problems under specific themes such as healthcare, security and surveillance, tourism, etc. Students with complementary technical expertise will form project teams to work on real-world projects under the supervision of CS professors and industrial partners. This first part focuses on the analysis of the real-world problems, formulation of the computing requirements of the desired solution that meets the user's needs, design of the computer systems according to the requirements, and evaluation of the design.

CS3282 Thematic Systems Project II

Modular Credits: 4

Workload: 2-2-0-4-2

Prerequisite(s): CS3281 and have passed at least two primary modules in a CS focus area. Student selection process will be enforced.

Preclusion(s): Nil

Cross-listing(s): Nil

This module is the second of a two-part series on the development of large-scaled computer systems to solve real-world problems under specific themes such as healthcare, security and surveillance, tourism, etc. Students with complementary technical expertise will form project teams to work on real-world projects under the supervision of CS professors and industrial partners. This second part focuses on the development of algorithms required for the systems, implementation and testing of the algorithms and the systems, and evaluation of the systems according to the users' requirements.

CS3343 Digital Media Production

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): SoC students: CS1020 or its equivalent; CNM students: NM2208

Preclusion(s): Nil

Cross-listing(s): Nil

Development of digital media products such as videos, games, animations and digital special effects require both technical skills and artistic creativity. Common to these different media is the process of digital media production. This module aims at introducing the process of digital media production, in particular, video production. It covers pre-production, production and post-production processes, focusing on main activities such as storyboarding, camera, lighting, audio/sound, directing, recording and digital editing. The students will learn both artistic expression and the technical skills of using digital equipment and software tools. They will also engage in hands-on practice of digital video production.

CS3882 Breakthrough Ideas for Digital Markets

Modular Credits: 4

Workload: 2-0-0-7-1

Prerequisite(s): Read and passed 80 MCs of modules. Students from Engineering, Science, and FASS with sufficient computing background and have read and passed 80 MCs of modules may also apply to read. Student selection process will be enforced.

Preclusion(s): Nil

Cross-listing(s): Nil

This module provides students the opportunity to explore and conceptualise new digital products or services that will impact people and enterprises. Students will cultivate the importance of thinking "design" for the purpose of developing valuable, captivating and usable digital products or services. The module will provide students with insights into the innovation process and case studies of

successful innovation. Exposure to ideas from leading companies and serial entrepreneurs will motivate ideation. Students will be required to benchmark their ideas for competitive positioning.

CS4201 Interactive Systems Project I

Modular Credits: 4

Workload: 1-0-0-5-4

Prerequisite(s): CS3248

Preclusion(s): CS4348

Cross-listing(s): Nil

This module is the first of a two-part series on the development of interactive systems for various applications. The aim of these modules is to allow students to apply design and engineering principles to interactive system development and management. This first part focuses on the design of interactive systems. The students will design an interactive solution, document the systems in terms of software/hardware framework, and implement a first-cut, low-fidelity prototype for evaluation purpose. Some formative evaluations will be performed to validate their design. Student selection will be enforced to ensure that they have the abilities to complete the projects.

CS4202 Interactive Systems Project II

Modular Credits: 4

Workload: 1-0-0-5-4

Prerequisite(s): CS4201

Preclusion(s): CS4348

Cross-listing(s): Nil

This module is the second of a two-part series on the development of interactive systems for various applications. The aim of these modules is to allow students to apply design and engineering principles to interactive system development and management. This second part focuses on the implementation of an interactive solution designed and documented in CS4201. In addition, the students will also learn to design and perform summative evaluations (such as controlled experiments) of their completed systems with real users. Student selection will be enforced to ensure that they have the abilities to complete the projects.

CS4203 Game Development Project I

Modular Credits: 4

Workload: 1-0-0-5-4

Prerequisite(s): CS4213

Preclusion(s): CS4343 or NM4343

Cross-listing(s): Nil

This module is the first of a two-part series on the development of digital games. The aim of these modules is to allow student teams to apply game design principles and algorithms to create a complete digital game. Each team will work on a game development project in a selected exploration theme related to game technology, platform or design. This first part focuses on game design aspects including character and level design, character and level modelling, storyboarding, and texture and lighting. Student selection will be enforced to ensure balance of students' ability to create games.

CS4204 Game Development Project II

Modular Credits: 4

Workload: 1-0-1-6-2

Prerequisite(s): CS4203

Preclusion(s): CS4343/NM4343

Cross-listing(s): Nil

This module is the second of a two-part series on the development of digital games. The aim of these modules is to allow student teams to apply game design principles and algorithms to create a complete digital game. Each team will work on a game development project in a selected exploration theme related to game technology, platform or design. This second part focuses on the game implementation aspects including real-time algorithms and data structures for behavioural and perception models, navigation, collision detection, animation and rendering. Student selection will be enforced to ensure balance of students' ability to create games.

CS4211 Formal Methods for Software Engineering

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS2103

Preclusion(s): Nil

Cross-listing(s): Nil

Before software can be designed, its requirements must be well understood. Before requirements can be expressed, the application domain must be similarly well understood. This course will cover some of the advanced and sound formal techniques of the three major phases of Software Engineering: Domain Engineering (e.g. ontology), Requirements Engineering (e.g. precise specifications), and Software Design (e.g. analyzable models and reasoning tools).

CS4212 Compiler Design

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): CS2104

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to introduce the principal ideas behind programme compilation, and discuss various techniques for programme parsing, programme analysis, programme optimisation, and run-time organisation required for programme execution. Topics covered include regular expressions, context-free grammars, lexical analysis, syntax analysis; different algorithms for parsing codes, such as top-down parsing, bottom-up parsing; translation to abstract syntax using modern parser generator technology, intermediate representation, semantics analysis, type system, un-optimised code generation, code optimisation, data-flow analysis, instruction scheduling.

CS4213 Game Development

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3241

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to introduce techniques for electronic game design and programming. Topics include game history, game design, game development environments, interactive fiction, game shell and engine, game programming (managing the frame loop, blitting and page flipping, sprite animation, clipping, and scaling), multi-player game, game production industry. Specific data structures and algorithms used by game software will also be covered: scene graph representation and rendering, geometric level of detail, terrain modelling and rendering, spatial sorting, dynamic object-object intersection, 2D/3D morphing, and techniques for special visual effects. Course projects are integral to the module.

CS4214 Formal Semantics

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): CS2104 or CS3212 or CS3234

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this course is to provide the basic mathematical techniques to study the semantics and logical reasoning of programmes and programming languages. This enables the students to understand semantics specifications and to develop new ones for new languages. The course also describes and compares various advanced programming language features. The course combines theory and practice. Topics covered include axiomatic, denotational and operational semantics, type systems, template meta-programming, staged/generic programming, XML and XML processing.

CS4215 Programming Language Implementation

Modular Credits: 4

Workload: 2-0-2-4-2

Prerequisite(s): CS2010 or its equivalent and CS2104

Preclusion(s): Nil

Cross-listing(s): Nil

This module provides the students with theoretical knowledge and practical skill in the implementation of programming languages. It discusses implementation aspects of fundamental programming paradigms (imperative, functional and object-oriented), and of basic programming language concepts such as binding, scope, parameter-passing mechanisms and types. It introduces the language processing techniques of interpretation, and compilation and virtual machines. The lectures are accompanied by lab sessions which will focus on language processing tools, and take the student through a sequence of programming language implementations. This module also covers automatic memory management, dynamic linking and just-in-time compilation, as features of modern execution systems.

CS4216 Constraint Logic Programming

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3234

Preclusion(s): Nil

Cross-listing(s) : Nil

This course introduces the programming methodology of Constraint Logic Programming (CLP). It first covers programming in PROLOG, the basic CLP programming language. The main part of the course covers modelling of complex problems using constraints and rules, and the use of advanced algorithms that are supported by the constraint solvers in modern CLP systems. Also covered are the mathematical foundations of CLP. Throughout the course, practical exercises are performed using a modern CLP

system such as CLP(R) or Eclipse.

CS4217 Software Development Technologies

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): CS3213

Preclusion(s): Nil

Cross-listing(s) : Nil

This module aims to provide students with an appreciation of the technologies and tools available in support of the software development life cycle. Through assignments and projects, students will learn various technologies and tools that dramatically improve the productivity of the development process and the quality of product. They will also gain an appreciation of how choosing the wrong technologies and tools can be disastrous to the project, and the pitfalls and opportunities for the automation of software development. Topics include cost benefit analysis of using automation tools, tool selection, implementation success criteria, tool evaluations, piloting tools and tool demos.

CS4220 Knowledge Discovery Methods in Bioinformatics

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): CS2220 or LSM2104

Preclusion(s): Nil

Cross-listing(s): Nil

With the advent of high throughput technologies (e.g. DNA chips, microarray, etc.), biologists are being overloaded with lots of information (e.g., gene expression data). To be able to make sense of these data, there is a need to have a systematic way to analyse them. This course is introduced to provide students with knowledge of techniques that can be used to analyse biological data to enable them to discover new knowledge. At the end of the course, students will be able to identify the relevant techniques for different biological data to uncover new information. Topics include: Clustering analysis, classification, association rule mining; support vector machines; Hidden Markov Models.

CS4221 Database Design

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS2102 or CS2102S

Preclusion(s): Nil

Cross-listing(s): Nil

This module addresses the design of relational databases and object oriented databases. Topics covered include: normalisation theory: functional, multi-valued and join dependency, normal forms, relational database schema design using decomposition method and synthesising method; entity-relationship approach: normal form entity-relationship diagram, its derivation, and its translation to relational, network, and hierarchical database schemas; schema integration: view integration and database integration, schema conflict resolution; nested relations: normal form nested relations, nested relations design using decomposition method and entity-relationship approach; object-oriented databases: basic concepts, inadequacies in object-oriented data models, inheritance conflict resolution, translate relational database schemas and entity-relationship diagrams to object-oriented database schemas.

CS4222 Wireless Computing & Sensor Networks

Modular Credits: 4

Workload: 2-0-2-4-2

Prerequisite(s): CG3204L or CS3103

Preclusion(s): Nil

Cross-listing(s): Nil

The primary goal of this module is to introduce students to two major types of wireless networks. First, concepts in cellular networking, including the various generations of cellular networks are introduced. Important concepts related to the design of air interfaces, MAC protocol, QoS, spectrum allocation, mobility management are presented. Second, the students are introduced to the emerging area of sensor networks. Here, the major topic covered are MAC, routing and transport protocols. In this module, there is a strong emphasis on exposing students to practical network system issues by encouraging them to build software prototypes as part of their assessment.

CS4223 Parallel Computer Architecture

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): (CS2106 or CG2271) and (CS3210 or CS3220 or CG3207)

Preclusion(s): Nil

Cross-listing(s): Nil

The world of parallel computer architecture has gone through a significant transformation in the recent years from high-end supercomputers used only for scientific applications to the multi-cores (multiple processing cores on a single chip) that are

ubiquitous in mainstream computing systems including desktops, servers, and embedded systems. In the context of this exciting development, the aim of this module is to examine the design issues that are critical to modern parallel architectures. Topics include instruction-level parallelism through static and dynamic scheduling, shared memory, message-passing, and data parallel computer architectures, cache coherence protocols, hardware synchronization primitives, and memory consistency models.

CS4231 Parallel and Distributed Algorithms

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3230 or CS3210

Preclusion(s): Nil

Cross-listing(s): Nil

This course will examine some fundamental issues in parallel programming and distributed computing, and the relationships between the two. Parallel programming: mutual exclusion, semaphores, consistency, wait-free synchronisation. Distributed computing: time, global state, snapshots, message ordering. Relationships: consensus, fault-tolerance, transactions, self-stabilisation.

CS4232 Theory of Computation

Modular Credits: 4

Workload: 2-1-0-3-3

Prerequisite(s): CS1231 or any Level-2000 MAxxxx module offered by the Mathematics Department.

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to provide students with a theoretical understanding of what can be computed, and an introduction to the theory of complexity. It aims to introduce

- (i) some standard formal models of computation so as to develop an understanding of what can or cannot be computed by various computing devices;
- (ii) some reasoning techniques commonly used in computer science; these include model equivalence, non-determinism, digitalisation, simulation and reduction; and
- (iii) the mathematical formulation of objects in computer science so as to study their properties.

CS4235 Computational Geometry

Modular Credits: 4

Workload: 2-2-0-4-2

Prerequisite(s): CS3230 and (MA1101R or MA1506)

Preclusion(s): Nil

Cross-listing(s): Nil

Computational geometry is the study of algorithms for solving geometric problems. This course introduces the main topics and techniques in this field. They will be presented in connection with applications in CAD, databases, geographic information systems, graphics and robotics. Students will learn the main algorithmic techniques for solving geometric problems and the related discrete geometric structures. At the end of this module, students will be able to design and analyse geometric algorithms and data structures, and to apply these techniques to solve problems arising in applications.

CS4236 Cryptography Theory and Practice

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS2107 and CS3230

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims to introduce the foundation, principles and concepts behind cryptology and the design of secure communication systems. The emphasis is on the formulation and techniques of various cryptographic primitives, and on the secure usage of such primitives to achieve the goals of confidentiality, integrity, and authenticity in both theoretical settings and practical scenarios. Basic topics include pseudorandom functions, symmetric key encryption, public key encryption, message authentication codes, hash functions, digital signatures, key exchange and PKI. Selected topics may include: secret sharing, TCP/IP security, Kerberos, SSL, trusted computing, side-channel attacks.

CS4237 Systems Modelling and Simulation

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): (ST1232 or ST2131 or ST2334) and (CS1020 or its equivalent). Preferably read CS3103 or CS3220 or CS4223.

Preclusion(s): Industrial Systems Engineering (ISE) students

Cross-listing(s): Nil

This course covers the methodology and techniques in systems modelling and the design of computer simulation models. At the end of the course, the students should be able to carry out a study of a system using computer simulation. Topics include: ways to study a system; modelling and simulation lifecycle; principles of discrete-event modelling and simulation; input data modelling, model

development and programming; model verification and validation; model output analysis, design of simulation experiments; comparison and evaluation of system design alternatives; applications of simulation in computer science.

CS4238 Computer Security Practice

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS3235

Preclusion(s): Nil

Cross-listing(s): Nil

This is a lab-based module with emphasis on hands-on experiences of computer security. The objective of this module is to familiarize the students with common attacks and protection mechanisms, as well as general system administration and development of secured software. Topics covered include network security, operating system security, and application security such as DNS attacks, memory-error exploits, and web application attacks. Students will learn through project assignments and defense competitions.

CS4240 Virtual Reality and 3-D Interaction

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3241

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to expose students to advanced 3D interactive techniques by focusing on a set of selective subjects: fundamentals of virtual reality, immersing devices (HMD, Gloves, magnetic trackers, stereo glasses and other forces) and multi-user systems, techniques for real time or fix frame rate simulation such as scene/object culling, representations of level of details (LOD), and various image based rendering methods based on the dimensionality of the Plenoptic function, and related sampling and re-sampling issues.

CS4241 Multimedia Information Retrieval

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3245 and CS3246

Preclusion(s): Nil

Cross-listing(s): Nil

With the proliferation of digital media, more and more information is available in non-textual forms. The ability to index, manage and retrieve media content is of paramount importance. This module introduces the theory, design and technologies of media search. It covers the design of media search engine, the extraction of media features and their indexing, media concept annotation, media search paradigms, and interactive search. It also covers the applications of media search in social media, enterprise and personal media.

CS4243 Computer Vision and Pattern Recognition

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): (CS1020 or its equivalent), (MA1101R or MA1506), (MA1102R or MA1505C or MA1505 or MA1521), and (ST1232 or ST2131 or ST2334)

Preclusion(s): Nil

Cross-listing(s): Nil

In this module, various methods for computers to understand and interpret the contents of images are investigated. The objective is to expose the students to the basic concepts underlying various computer vision techniques and the application of current techniques for problem solving. Topics covered include morphological operations, convolution and cross correlation, edge and corner detection, colour, texture, motion, image registration and mosaicking, 3D vision, camera calibration and 3D reconstruction, eigenface and pattern recognition. Laboratory exercises and projects are included for the students to solve practical problems using computer vision and image processing software packages.

CS4244 Knowledge-Based Systems

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3243

Preclusion(s): Nil

Cross-listing(s): Nil

This is a module that contains both the theory and practice of building knowledge-based systems. The aim of this module is to prepare students so that they can design and build knowledge-based systems to solve real-world problems. The module starts with motivations, background and history of knowledge-based system development. The main content has five parts: rule-based programming language, uncertainty management, knowledge-based systems design, development and life cycle, efficiency in rule-

based language and knowledge-based systems design examples.

CS4245 Multimedia E-Learning Environments

Modular Credits: 4

Workload: 2-1-1-4-3

Prerequisite(s): CS3240 and CS3248

Preclusion(s): Nil

Cross-listing(s): Nil

This course teaches students how to design and develop multimedia and Internet-based learning environments to support effective online learning and training. It has two main parts. The first part addresses the issue of pedagogy in learning and training. The second part deals with different types of educational technologies, such as interactive learning environments, tutoring systems, and simulation-based learning environments. It will also address the design, development, and appropriate use of computing technologies for instruction and learning. Special emphasis will be given to multimedia and Internet-based learning environments. Students will be required to complete a project using an appropriate authoring tool.

CS4246 AI Planning and Decision Making

Modular Credits: 4

Workload: 2-1-0-4-3

Prerequisite(s): (MA2216 or ST2131 or ST2334) and CS3243

Preclusion(s): Nil

Cross-listing(s): Nil

This module introduces the major concepts and paradigms in planning and decision making in complex environments. It examines issues, challenges, and techniques in problem representation, goal or objective specification, response selection, and action consequence for a wide range of strategic and tactical planning and decision making situations. Topics covered include deterministic and non-deterministic planning, practical planning, and acting under resource constraints and uncertainty, expected utility and rational decision making, decision networks, Markov decision processes, elementary game theory, and multi-agent planning and decision making.

CS4247 Graphics Rendering Techniques

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3241

Preclusion(s): Nil

Cross-listing(s): Nil

This module provides a general treatment of real-time and offline rendering techniques in 3D computer graphics. Specific topics include the raster graphics pipeline, viewing and transformation, real-time mapping techniques, real-time shadow algorithms, local reflection models, global illumination, distributed ray tracing, photon mapping, radiosity, volume rendering, image-based rendering and modelling, and strategies for anti-aliasing and photo-realism.

CS4248 Natural Language Processing

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): (CS3243 or CS3245) and (ST1232 or ST2131 or ST2334)

Preclusion(s): Nil

Cross-listing(s): Nil

This module deals with computer processing of human languages, emphasising a corpus-based empirical approach. The topics covered include:

- (i) Linguistic essentials.
- (ii) Basic techniques and algorithms: Hidden Markov model, Viterbi algorithm, supervised learning algorithms.
- (iii) Words: part-of-speech tagging.
- (iv) Syntax: noun phrase chunking, named entity tagging, parsing (top down, bottom up, probabilistic).
- (v) Semantics: word sense disambiguation.
- (vi) Pragmatics: discourse, co-reference resolution.
- (vii) Applications: text categorisation, text summarisation, language identification, information extraction, question answering, machine translation.

CS4249 Design of Advanced User Interfaces

Modular Credits: 4

Workload: 2-1-1-4-3

Prerequisite(s): CS3240 and CS3248

Preclusion(s): Nil

Cross-listing(s): Nil

As computers become embedded and pervasive, the design of their interface has become increasingly specialised to meet specific

task needs while remaining subject to the overall requirement of usability. This course will expose students to a broad range of advanced and novel interfaces that are having an impact both at work and in play. It will focus on the design of such interfaces and emphasise the importance of usability and task fit. Students will be required to read critically and extensively and contribute to class discussion. They will also be required to complete a significant review or design a project.

CS4271 Critical Systems and Their Verification

Modular Credits: 4

Workload: 2-0-1-3-3

Prerequisite(s): CS1104 or CS2100 or EE2006 or EE2020) and (CS1231 or MA1100)

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to introduce formal verification techniques for validating safety critical reactive systems with specific focus on embedded systems. It covers an automated formal verification technique called Model Checking, which is based on state space search. The different parts of the course will touch upon:

- (i) formal modelling
- (ii) verification via Model Checking
- (iii) state space reduction techniques to make model checking space/time efficient and
- (iv) specific issues in validation of reactive embedded systems.

CS4273 Embedded Software Design Project

Modular Credits: 4

Workload: 1-1-2-5-1

Prerequisite(s): (CG2271 or CS2271) and (CS3215 or CS3202)

Preclusion(s): Nil

Cross-listing(s): Nil

This module will cover the design, construction and validation of embedded systems. Students will embark on a good-sized embedded system project on an ARM-based platform, which will include producing detailed specifications and design documents, implementing the application system, and demonstrating that their prototype meets the specifications. Students will gain hands-on experience of working in teams to build a complete embedded system and understand the interplay between the hardware platform, real-time operating systems (RTOS) and the embedded software. Experience accrued will include adapting RTOS to specific embedded environments, and low level device programming. Example projects include calculators, MP3 players, and digital clocks.

CS4274 Mobile and Multimedia Networking

Modular Credits: 4

Workload: 2-1-2-3-2

Prerequisite(s): CG3204L or CS3103

Preclusion(s): Nil

Cross-listing(s): Nil

The first part of this module deals with mobility and wireless technology. It introduces the development of the mobile IP protocol, and addresses the practical application of mobile IP in real-world networking environments. It looks at advanced mobile IP features, including NAT traversal, integration with IPSec, and network mobility. In the second part, the module deals with computer and multimedia networks, and applications associated with multimedia networking. Characteristics of real-time and multimedia traffic and concepts of QoS for multimedia data transmission are discussed. It also deals with transmission of multimedia traffic over various networks, related protocols, services, and applications.

CS4275 Programming Real-time Systems

Modular Credits: 4

Workload: 2-1-0-2-5

Prerequisite(s): (CS1020 or its equivalent) and CS2106

Preclusion(s): Nil

Cross-listing(s): Nil

Developing applications for real-time embedded systems require programming languages and abstractions which are substantially different from those used for developing desktop applications. This module will introduce different real-time programming models, programming languages corresponding to these models, and techniques for programming with real-time operating systems. The topics covered will include principles of synchronous programming using Lustre, the time-triggered programming model and the recently developed Giotto language, and programming languages based on the model of scheduled computation such as Real-Time Java. This module will be suitable for senior undergraduates and graduate students interested in embedded systems and programming languages.

CS4340 Digital Special Effects

Modular Credits: 4

Workload: 2-0-1-5-2

Prerequisite(s): CS3343 and (CS4243 or CS4247 or CS4342).

Preclusion(s): CS5245

Cross-listing(s): Nil

This module aims at teaching multimedia techniques for creating digital special effects video. It allows the students to explore their creativity while extending their skills in multimedia technologies. Topics covered include elements of special effects, camera work, storyline and storyboard, digital compositing, matchmoving, video effects, CG effects, 2D/3D morphing, realistic rendering, sound effects, case studies. The students are required to analyse and critique special effects in movies. The module culminates in a short video project that demonstrates the students' creativity and innovation in using various techniques to create a captivating and stunning digital special effects video.

CS4342 3D Modelling and Animation

Modular Credits: 4

Workload: 2-0-2-4-2

Prerequisite(s): CS3241

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims to provide fundamental concepts in 3D modelling and animation. It also serves as a bridge to advanced media modules. After taking this module, students should be able to use these concepts to easily build or work with digital models, manipulate the models by means of computer deformation and animation, and use lighting and rendering techniques to create appealing scenes. Topics include coordinate spaces, transforms, 3D model representations, hierarchical structures, deformation, procedural modelling, particle systems, character animation, shading networks, lighting, and scripting concepts.

CS4344 Networked and Mobile Gaming

Modular Credits: 4

Workload: 2-1-2-0-5

Prerequisite(s): (CG2271 or CS2106) and (CG3204L or CS3103)

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims at providing students a deep understanding of various technical issues pertaining to the development of networked games and mobile games. Students will be exposed to concepts from distributed systems, operating systems, security and cryptography, networking and embedded systems. In particular, issues such as game server architectures (mirrored, centralised, peer-to-peer etc.), consistency management (bucket synchronisation, dead reckoning etc.), interest management, scalability to large number of clients (C10K problem), cheat prevention and detection, power management, will be discussed.

CS4345 General-Purpose Computation on GPU

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): CS3241

Preclusion(s): Nil

Cross-listing(s): Nil

With the advancements in the technology of graphics processing units (GPUs), many computations can be performed faster on the GPUs than the CPUs. They are also programmable, making them useful for not just computer graphics processing but also general-purpose computations. Therefore, they are a natural choice as high-speed coprocessors to the CPUs in various applications. This module introduces the architecture of GPU, programme-writing on GPU using high-level language such as Cg, and the use of GPU in applications including computer graphics, games, scientific computation, and image processing.

CS4346 Game Console Programming

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): CS4213

Preclusion(s): Nil

Cross-listing(s): Nil

This module will dissect hardware, software and development cycles for one or more leading game consoles available in the industry. The objective is to expose students to concepts of systems architecture, resource management, threading, streaming, and content optimisation for high throughput and constrained memory/power platforms. Students will be exposed to hands-on programming assignments and mini-projects on selected consoles with SDKs secured under Non-Disclosure Agreement with console manufacturers.

CS4347 Sound and Music Computing

Modular Credits: 4

Workload: 2-0.5-0.5-4-3

Prerequisite(s): (CS1020 or its equivalent), (MA1505 or MA1521 or MA1102R) and (MA1101R or MA1506).

Preclusion(s): Nil

Cross-listing(s): Nil

This module introduces the fundamental technologies employed in sound and music computing which are grouped into three major areas: Sound, Music, and Interaction. It begins with an introduction to sound production, propagation and perception, followed by digital sound recording, editing, post-processing and compression. Its core components consist of the analytic and synthetic approaches of sound and music. The analytic approach pertains to analysis and understanding, whereas the synthetic approach pertains to generation and processing. Interaction aspects include multimodal mobile music interface and sound interaction design. Finally, music information retrieval will be introduced as an application of analytic techniques.

CS4349 Media Research Project

Modular Credits: 12

Workload: 0-1-3-12-4 (First Sem: Team work project)

Workload: 10 (Second Sem: Independent project)

Prerequisite(s): CS3248 or CS4213. Department approval is required.

Preclusion(s): CP4101 or CS4101 or XFC4101

Cross-listing(s): Nil

This module aims to build up students' ability in doing independent research in the media area by immersing themselves in team-based media development projects in the first semester, and independently advancing the media technology they have explored during the team-project phase in the second semester. The project may be proposed jointly by staff, students and industrial partners. Towards the end of the module, students are required to submit a report describing their work, and give an oral presentation and demonstration before a panel of examiners.

CS4880 Digital Entrepreneurship

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisites: Students in their 3rd year of study in science, technology or business

Preclusion(s): Nil

Cross-listing(s): Nil

The course will cover trends in the digital marketplace and emerging high-growth opportunities for digital businesses. The course will highlight issues facing companies with new products and services in an ever-changing digital marketplace. While the course will provide an overview on structuring of new ventures, the primary focus will be on opportunity identification and sources of competitive differentiation, particularly as they relate to digital innovation. To hone these skills the students will communicate by crafting a business plan.

CSxxxR (e.g. CS3230R)

Modular Credits: 1

Workload: 0-0-0-2-1

Prerequisites: Co-read host module. Student selection process is enforced

Preclusion(s): Nil

Cross-listing(s): Nil

This 1-MC module adds a research component to the host module, enabling students to acquire more in-depth understanding of the research issues pertaining to the subject matter.

CS5201 Foundation in Theoretical CS

Modular Credits: 4

Workload: 0-0-0-0-10

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The purpose of this module is to test the students on basic concepts in theoretical computer science. In particular, the students will be tested on the following areas:

- (i) Design and Analysis of Algorithms
- (ii) Theory of Computation
- (iii) Programming Languages D. Logic and Formal Systems.

CS5202 Foundation in Computer Systems

Modular Credits: 4

Workload: 0-0-0-0-10

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The purpose of this module is to test the students on basic concepts in computer systems. In particular, the students will be tested on the following topics:

- (i) Advanced Operating Systems
- (ii) Computer Networks II
- (iii) Database Management Systems
- (iv) Computer Architecture.

CS5205 Foundation in Programming Languages

Modular Credits: 4

Workload: 2-0-0-3-5

Prerequisite(s): CS3212

Preclusion(s): Nil

Cross-listing(s): Nil

This course is concerned with the practical foundations for the design, implementation and application of programming languages. The course will cover important language concepts that facilitate abstraction, reuse and reasoning in the software construction process. A good understanding of language foundation will help with the design of many little languages for domain-specific applications. The course will show how to translate programs to kernel form as an instance of language compilation, and shall look at the role that type system plays towards eliminating some program errors. Formal reasoning of program code can also be applied through logical formulae that can describe the intended behaviour of programs. Both Hoare and separation logic are introduced to allow formal reasoning and capture of important program properties.

CS5206 Foundation in Algorithms

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): CS2010 or its equivalent and CS3230

Preclusion(s): Nil

Cross-listing(s): Nil

This module is a foundation module for graduate students in all areas of CS that aims to provide all graduate students in computer science with the necessary skills for algorithmic problem-solving in all areas of computer science. The module presents intermediate level material on design and analysis of algorithms, with emphasis on efficient algorithms and data structures. It includes the implementation and use of advanced data structures and algorithms in advanced software development. The topics covered include asymptotics for analysis of algorithms, the major algorithm design paradigms, amortised complexity analysis, problem complexity and NP-completeness, approximation algorithms.

CS5207 Foundation in Operating Systems

Modular credits: 4

Workload: 2-0-0-3-5

Prerequisite(s): CS3221

Preclusion(s): Nil

Cross-listing(s): Nil

This module is an introductory course to fundamental and advanced operating systems techniques aimed at computer science graduate students. The topics covered include threads, scheduling, concurrency, memory management, and storage systems, software management, and security. After taking the module, students are expected to understand common design principles used, the common issues and problems in computer systems, and be able to design and evaluate a system.

CS5208 Foundation in Database Systems

Modular credits: 4

Workload: 2-0-0-5-3

Prerequisite(s): CS3223

Preclusion(s): Nil

Cross-listing(s): Nil

This is a seminar-based course that introduces our graduate students to database fundamentals. The goal is to cover a broad range of basic topics in database systems to ground the students in the field and to prepare them for research in databases. The course is based on lively discussion of important papers from the literature, covering basic topics such as query processing, optimisation, concurrency control, recovery, transaction management, and advanced topics such as data mining, distributed databases and data streams.

CS5209 Foundation in Logic & AI

Modular credits: 4

Workload: 2-1-0-2-6

Prerequisite(s): CS3234

Preclusion(s): Nil

Cross-listing(s): Nil

Many functionalities which were previously handled by electrical or mechanical devices are now computer-controlled. In order to develop reliable computer systems, we need to have the foundations for logically reasoning about their behaviour. This module introduces the students to mathematical logic and its usage in modelling/validating computer systems.

CS5214 Design of Optimising Compilers

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3212 or CS4212

Preclusion(s): Nil

Cross-listing(s): Nil

The performance gap between optimised and unoptimised code continues to widen as modern processors evolve. Notably, the emerging explicitly parallel instruction computing (EPIC) processors are significantly dependent on a range of aggressive programme optimisations to yield performance. This module provides an in-depth study of code optimisation techniques used in compilers for state-of-the-art processors. Topics covered include structure of an optimising compiler, the programme dependence graph, front end optimisations, instruction scheduling, register allocation, compiling for EPIC processors including predicated execution and software pipelining with hardware support, loop optimisations, dataflow analysis and optimisation, optimisations for the memory hierarchy, and automatic parallelisation.

CS5215 Constraint Processing

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS2104 or CS3212

Preclusion(s): Nil

Cross-listing(s): Nil

Constraint programming is an alternative approach to computing in which the programming process is limited to a generation of requirements (constraints) and to solving of them by general methods and domain dependent methods. The aim of this course is to discuss the basic aspects of constraint programming. Students will learn problem modelling by means of constraints and the main techniques used to solve such systems of constraints. The course will focus on the fundamental notions of constraint satisfaction problems, local consistency, constraint propagation, complete and incomplete constraint solvers, and various search methods.

CS5218 Principles of Programme Analysis

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3212 or CS4212

Preclusion(s): Nil

Cross-listing(s): Nil

Programme analyses are static (compile-time) techniques for computing approximate and yet reliable information about the dynamic behaviour of programmes. This module lays the foundation for study of programme analysis. It covers the essential mathematics upon which programme analyses are built, and provides an overview of different approaches to programme analysis. Topics include: Partially ordered sets, induction and co-induction, data flow analysis, constraint based analysis, abstract interpretation, and type and effect systems. Students with interest in programming language design and compiler design will find this module beneficial.

CS5219 Automated Software Validation

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): CS3212 or equivalent

Preclusion(s): Nil

Cross-listing(s): Nil

The immense growth in the complexity of software has increased the scope of errors, which are often critical. The nature of these errors is diverse, resulting from the diversity of the various classes of software: sequential, multithreaded, reactive and real-time. In this course, we will study techniques for verification, run-time monitoring and debugging of software which help us to give certain guarantees against such errors. The focus will be on automated validation techniques. This is a research-oriented course in programme validation and verification, but parts of it are useful for graduate students working in other areas.

CS5220 Databases and the Web

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): CS3223 or an equivalent course on database system implementation

Preclusion(s): Nil

Cross-listing(s): Nil

This course covers novel application of database concepts and techniques to the processing, dissemination, and integration of data on the Web. Students will learn about the research issues and state-of-the-art techniques that arise from the intersection of database and Web technologies. Topics to be covered include Web technologies (XML, specification languages such as DTD and XML Schema, query languages such as XPath, XQuery) and the application of database technologies (query optimisation and evaluation techniques) to manage and process data in Web-based applications.

CS5222 Advanced Computer Architecture

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): CS2106 and (CS3220 or CS4223)

Preclusion(s): Nil

Cross-listing(s): Nil

The aim of this module is to introduce the state-of-the-art architectural advances underlying the current generation of computing systems. A review of pipelined processor design and hierarchical memory design is followed by advanced topics including exploitation of instruction-level parallelism through dynamic instruction scheduling and speculation, exploiting thread-level parallelism through multiprocessors, and optimisations for memory and storage subsystems. Throughout the module, particular emphasis will be placed on cost-performance-power-reliability trade-offs in designing the different architectural components.

CS5223 Distributed Systems

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS2106, CS3211

Preclusion(s): Nil

Cross-listing(s): Nil

The topic of Distributed Systems is now garnering increasing importance, especially with the advancement in technology of the Internet and WWW. The aim of this module is to provide students with basic concepts and principles of distributed operating systems, interprocess communications, distributed file systems, shared data, and the middleware approach. The module is taught in seminar style, and several case studies are included, e.g. CORBA. Topics: Introduction — Characteristics of Distributed Systems; Process Management Communication in Distributed Systems; Distributed Synchronisation; Distributed Real-time Systems; File Systems; Naming Security; Fault Tolerant Distributed Systems; Distributed Simulation; WWW as an application of Distributed System.

CS5225 Parallel & Distributed Database Systems

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3223

Preclusion(s): Nil

Cross-listing(s): Nil

This module addresses issues in management of large volume shared data in parallel and distributed environments. Topics covered include: Overview of database and computer network concepts; Transparency in a distributed DBMS; Distributed DBMS architecture. Distributed database design: Alternative design strategies; Distributed design issues; Fragmentation; Data allocation. Distributed query processing: Factors governing query optimisation; Centralised query optimisation; Ordering of fragment queries; Distributed query optimisation algorithms. Concurrency control: Concurrency control in centralised database systems; Concurrency control in DDBSs; Distributed concurrency control algorithms; Deadlock management. Parallel Database: Parallel architectures; parallel query processing and optimisation; load balancing.

CS5226 Database Tuning

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3223, CS4221

Preclusion(s): Nil

Cross-listing(s): Nil

This module is concerned with the performance-related database administration issues. The topics include: an overview of query optimisation techniques, physical database design, system configuration, buffer management, performance analysis and tuning techniques.

CS5228 Knowledge Discovery and Data Mining

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS1231, CS3243, (CS2102 or CS2102S) and (ST1232 or ST2131 or ST2334)

Preclusion(s): Nil

Cross-listing(s): Nil

This course introduces fundamental principles behind data mining and efficient techniques for mining large databases. It provides an overview of the algorithmic aspect of data mining: its efficiency (high-dimensional database indexing, OLAP, data reduction, compression techniques) and effectiveness (machine learning involving greedy search, branch and bound, stochastic search, parameter optimisation).

Efficient techniques covered include association rules mining (Apriori algorithm, correlation search, constrained association rule discovery), classifier induction (decision trees, RainForest, SLIQ; Support vector machine; Naive Bayesian; classification based on association / visualisation), cluster analysis (kmeans, k-medoids, DBSCAN, OPTICS, DENCLUE, STING, CLUSEQ, ROCK etc), and outliers/deviants detection (LOF, Distance-based outlier etc.).

CS5229 Advanced Computer Networks

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): CS3103 or EE4210

Preclusion(s): Nil

Cross-listing(s): Nil

This course covers advanced fundamental principles of computer networks and techniques for networking. The goal of this course is to teach these fundamentals/techniques that will remain important and relevant regardless of the hot topics in networks and networking. Briefly, the topics include advanced network architecture and design principles, protocol mechanisms, implementation principles and software engineering practices, network algorithmic, network simulation techniques and tools, performance analysis and measurement, and protocol specification/verification techniques.

CS5230 Computational Complexity

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS3231 or CS4232

Preclusion(s): CS4230

Cross-listing(s): Nil

The aim of this module is to study the various measures of difficulty of problem-solving in computing, and to introduce some techniques in theoretical computer science such as non-determinism, digitalisation, simulation, padding, reduction, randomisation and interaction.

Topics covered include: space and time complexity - the classes P, NP, co-NP, PSPACE, EXP, etc.; tape compression; linear speedup; polynomial reduction; Cook's theorem; Savitch's theorem; translation lemma; Gap theorem; NP-completeness and NP-hard problems; probabilistic complexity classes; approximation algorithms; and interactive protocols.

CS5231 Systems Security

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): CS1231, CS2105 and CS2106

Preclusion(s): Nil

Cross-listing(s): Nil

This module introduces fundamental notions and requirements in computer security, such as the concepts of confidentiality, integrity and availability, and the mechanisms that provide security in various systems and applications. To illustrate relevant concepts, selected topics in information security, including symmetric key cipher and PKI, operating system security, network security, web security, and database security will be covered. Case studies of existing systems, international standards such as IPSec, and well-known attacks like phishing and buffer overflow will also be covered.

CS5232 Formal Specification & Design Techniques

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS1231 or CS3234

Preclusion(s): Nil

Cross-listing(s): Nil

The primary role of the formal specification is to provide a precise and unambiguous description of a computer system. A formal specification allows the system designer to verify important properties and detect design error before system development begins. The objective of this course is to study various formal specification and design techniques for modelling (1) object-oriented systems, (2) real-time distributed systems, and (3) concurrent reactive systems. The course will focus on the state-based notations Z/Object-Z, event-based notation CSP/Timed-CSP. Graphical modelling notations, such as StateChart and UML (Unified Modelling

Language) will also be addressed.

CS5233 Simulation and Modelling Techniques

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): (CS1020 or its equivalent) and (MA1102R or MA1505 or MA1505C or MA1521) and (MA1101R or MA1506) and (ST1232 or ST2131 or ST2334)

Preclusion(s): Nil

Cross-listing(s): Nil

This course aims to provide students with a working knowledge of applying simulation techniques to model, simulate, and study complex systems. It covers techniques in simulation model design, model execution and model analysis. Model design techniques include conceptual models, declarative models, functional models, constraint models, and multi-models. Model execution techniques include serial and parallel discrete-event simulation algorithms. Topics in model analysis include input-output analysis and experiment design. Students will have hands-on experience using a simulation package that we have developed.

CS5234 Combinatorial and Graph Algorithms

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3230

Preclusion(s): CS4234

Preclusion(s): Nil

Cross-listing(s): Nil

This course presents advanced material on the design and analysis of combinatorial algorithms with emphasis on efficient algorithms and data structures. This course is meant for students who intend to (i) do research in computer science in general, and algorithm design in particular or (ii) do advanced application/software development in other areas of computer science. (It assumes that the student has already done one course on design and analysis of algorithms equivalent to CS3230.)

CS5235 Approximation Algorithms

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): CS3230 and (MA1101R or MA1506)

Preclusion(s): Nil

Cross-listing(s): Nil

Many optimisation problems are known to be NP-hard. Therefore it seems unlikely that efficient algorithms to solve them will ever be found. One way of dealing with these problems is to design polynomial time algorithms that give a provably good approximation of the optimal solution. This module will introduce the main techniques for designing such algorithms. The main topics covered are greedy algorithms, layering, polynomial time approximation schemes, (randomised) rounding and LP-relaxation. These notions will be applied to various combinatorial optimisation problems, including set cover, shortest superstring, MAX-SAT, multiway cut and metric TSP.

CS5237 Computational Geometry and Applications

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS1231 and CS3230

Preclusion(s): Nil

Cross-listing(s): Nil

The course aims to provide students with a geometric viewpoint in problem-solving. It lays a foundation for solving problems with computational geometric methods, and bridges the gap between theoretical computer science and the real applications by introducing application areas, such as bio-geometric modelling, computer graphics and mesh generation, as well as other engineering problems such as reverse engineering. Topics include: convex-hull algorithms, simplicial complexes, union of balls, Voronoi diagram, Delaunay triangulation, lifting and projecting, alpha shape, surface reconstruction, sphere algebra, orthogonality and complementarity, molecular skin surfaces, curvatures and surface meshing, deformation and morphing, etc.

CS5238 Advanced Combinatorial Methods in Bioinformatics

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3230

Preclusion(s): Nil

Cross-listing(s): Nil

Biology data are too enormous. Handling them using brute-force approaches becomes impossible and efficient algorithms are required. This module is an in-depth study of some of these advanced algorithms. Through the course, students are not only taught to understand these algorithms in detail, but are also given chances to solve some research problems in this field. Topics include sequence comparison, structure comparison and prediction, phylogenetic tree reconstruction and comparison, sequencing by

hybridisation, Genome rearrangements, gene network, microarray.

CS5239 Computer System Performance Analysis

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS1020 or its equivalent

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to provide students a working knowledge of computer performance evaluation and capacity planning. They will be able to identify performance bottlenecks, to predict when performance limits of a system will be exceeded, and to characterise present and future workload to perform capacity planning activities. Topics include: performance analysis overview; measurement techniques and tools including workload characterisation, instrumentation, benchmarking, analytical modelling techniques including operational analysis, stochastic queuing network analysis; performance of client-server architectures; capacity planning; case studies.

CS5240 Theoretical Foundation of Multimedia

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): (CS1020 or its equivalent) and (MA1102R or MA1505 or MA1505C or MA1521) and (MA1101R or MA1506) and (ST1232 or ST2131 or ST2334)

Preclusion(s): Nil

Cross-listing(s): Nil

The module lays the theoretical foundation for graduate students to do research in multimedia: images, videos, audio, speech, graphics and text documents. The module covers the main theoretical issues common to various multimedia research. These issues provide a general framework within which specific techniques in particular research areas can be understood. Topics include: vector and signal representations of multimedia, spatial and frequency analyses, models and parameter estimation methods. Examples will be drawn from different types of media. Upon completion, students will be well-grounded to pursue further research in computer vision, graphics, natural language processing, audio analysis and multimedia applications.

CS5241 Speech Processing

Modular Credits: 4

Workload: 2-0-0-3-5

Prerequisite(s): (CS1020 or its equivalent) and CS1231 and (MA1102R or MA1505 or MA1521) and (MA1101R or MA1506)

Preclusion(s): Nil

Cross-listing(s): Nil

This module exposes the graduate students to the fundamental theory of speech processing, focusing primarily on automatic speech recognition. Upon completion of this module, students should be able to perform research on speech recognition topics and commercial speech technology development. Topics covered by this module include: speech signal processing, automatic speech recognition (ASR), continuous speech recognition, acoustic modelling using the Hidden Markov Model (HMM), language modelling for ASR and advanced speech recognition techniques for state-of-the-art large vocabulary continuous speech recognition (adaptation and robustness, discriminative training and decoding strategies).

CS5242 Advanced Neural Networks

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3244

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to examine advanced research topics in two major aspects of neural networks' functionality: problem-solving and modelling. It emphasizes the application of neural network techniques to interesting and important problems that may be difficult to handle using traditional methods. Topics covered under problem-solving include classification, clustering, content-addressable memory, reinforcement-learning, control, time series. Topics covered under modelling include Grossberg networks (instars, outstars, cooperative-competitive networks) data encoding, knowledge representation, modelling behaviour and cognitive functions.

CS5243 3D Game Programming Technology

Modular Credits: 4

Workload: 2-0-2-4-2

Prerequisite(s): CS3241

Preclusion(s): Nil

Cross-listing(s): Nil

This module focuses on techniques employed in 3D game engines to achieve real-time rendering. Major topics include game engine architecture; object representations and scene graph; level-of-detail control; terrain processing; visibility computation; image-based

rendering; collision detection; real-time shadowing; rendering effects and GPU programming; modelling, sound, lighting and interactive control; animation and dynamic; networked multi-player games; and AI techniques. Upon completing the module, students will be able to design and build game engines from scratch, and to research and develop new game engine techniques.

CS5246 Text Processing on the Web

Modular Credits: 4

Workload: 2-0.5-0-5.5-2

Prerequisite(s): CS2103 and (MA1101R or MA1506 or ST1232 or ST2131 or ST2334)

Preclusion(s): Nil

Cross-listing(s): Nil

Most information on the web is in the form of encoded free-text formats. Current trends are towards high-level and semantic encoding of text information, and towards the integration of wired and wireless web environments. There is a need to classify and abstract information for display on wide variety of devices with wide ranging processing power and display capabilities. This module introduces the concepts and techniques for the analysis, representation, retrieval, classification and summarisation of unstructured textual information. Upon completion, the students should have the competence to design and implement text processing and mining systems and search engines on the web.

CS5247 Motion Planning and Applications

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): (CS1020 or its equivalent) and (MA1101R or MA1506)

Preclusion(s): Nil

Cross-listing(s): Nil

Motion is ubiquitous in the physical world. How many manoeuvres does it take to park a car in a tight spot? How can the motion of digital movie actors be synthesized automatically? What can robots do to avoid running into people walking around? How do molecules change shape over time? This module presents a coherent computational framework for this type of questions. The foundation of the framework and the state-of-the-art algorithms are illustrated in the context of several important applications, including robotics, computational biology, and computer animation. The module covers both classic results and, advances from recent research.

CS5248 Systems Support for Continuous Media

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): CS2106 and CS3103

Preclusion(s): Nil

Cross-listing(s): Nil

This module is targeted at computer science graduate students and covers the major aspects of building streaming media applications -- from coding to transmission to playback. Issues such as transport protocols, control protocols, caching, buffering, synchronisation and adaptations will be examined.

CS5249 Audio in Multimedia Systems

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): (CS1020 or its equivalent) and CS1231 and (MA1102R or MA1505 or MA1505C or MA1521) and (MA1101R or MA1506)

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims at providing students with an in-depth understanding of modern audio technologies, ranging from low-level audio representation to high-level content analysis; and from basic waveform to advanced audio compression and compressed domain processing. Upon completion of this module, students should be able to perform research such as narrowing the semantic gap between low-level features and high-level concepts. Topics include: discretisation, sampling, audio formats, audio synthesis, spatial audio, feature extraction, speech recognition, audio segmentation and summarisation, source separation, and audio compression.

CS5270 Verification of Real-Time Systems

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): (CS3220 or CS4223) and CS3234

Preclusion(s): Nil

Cross-listing(s): Nil

This one-semester first-year graduate course will provide an introduction to the analysis and verification of hard real-time systems. These are systems typically running embedded distributed applications that must meet their temporal constraints in a range of anticipated load and fault scenarios. The course will concentrate on specification and verification aspects of distributed real-time applications. The focus will be on the tools and techniques based on timed automata usage, where one can verify that the

scheduled behaviour of a realtime distributed system will meet its critical timing constraints. The overall goal is to provide the student with the current scientific and engineering insights that are relevant for the analysis and verification of distributed embedded real-time systems.

CS5271 Performance Analysis of Embedded Systems

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): (CS2271 or CG2271 or CS3220 or CS4223) and CS4212

Preclusion(s): Nil

Cross-listing(s): Nil

Modern embedded systems are heterogeneous collections of multiple hardware and software components, which might be designed by different vendors and have different interfaces. This heterogeneity, coupled with the complexity of embedded software and the complex features of modern processors make performance analysis of such systems a difficult problem. In recent years, there has been a lot of work in this area, especially because of its practical importance. In this course, we will discuss some of this work with the aim of getting a broad overview of this area. These will include formal models, algorithms, various simulation techniques, tools and case studies in the specific context of embedded systems, which significantly differ from techniques used for the performance analysis of general computer systems. Our focus will be on system-level design techniques, with the aim of critically accessing known models and methods in terms of their generality and ability at different stages of an embedded system design process. This course will be suitable for both graduate students and honours-year undergraduate students, who are interested in the general area of Computer Engineering. The projects/assignments will consist of a mix of theory and implementation, and there will be enough flexibility to incline more towards one or the other direction.

CS5272 Embedded Software Design

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): (CS1020 or its equivalent) and (CS1104 or CS2100)

Preclusion(s): Nil

Cross-listing(s): Nil

This course focuses on the design and implementation of software for programmable embedded systems. Embedded computing systems hidden inside everyday electronic devices such as handphones, digital cameras etc. are becoming more and more prevalent. However, the heterogeneous nature of the underlying hardware as well as tight constraints on size, cost, power, and timing pose significant challenges to embedded software development. This course presents techniques that address these distinctive characteristics of embedded software implementation. Topics include embedded software development for programmable processors and reconfigurable hardware, component-based design, optimisations for performance, power, code size, operating system issues, and case studies of available systems.

CS5321 Network Security and Management

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): CS4236

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to introduce students to the various issues that arise in securing and managing networks, and study the state-of-the-art techniques for addressing these challenges. A number of most damaging attacks on computer systems involve the exploitation of network infrastructure. This course provides an in-depth study of network attack techniques and methods to defend against them. Topics include basic concepts in network security and management; firewalls and virtual private networks; network intrusion detection; denial of service (DoS); traffic analysis; secure routing protocols; protocol scrubbing; and advanced topics such as wireless network security.

CS5322 Database Security

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): CS3223

Preclusion(s): Nil

Cross-listing(s): Nil

Database security has a great impact on the design of today's information systems. This course will provide an overview of database security concepts and techniques, and discuss new directions of database security in the context of Internet information management. Topics covered include: access control models for DBMSs, inference controls, XML database security, encrypted databases, digital credentials and PKIs, trust in open systems, and peer-to-peer system security.

CS5340 Uncertainty Modelling in AI

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass (CS1231 or MA1100) and (ST1232 or ST2131 or ST2334) and CS3243

Preclusion(s): Nil

Cross-listing(s): Nil

The module covers modelling methods that are suitable for reasoning with uncertainty. The main focus will be on probabilistic models including Bayesian networks and Markov networks. Topics include representing conditional independence, building graphical models, inference using graphical models and learning from data. Selected applications in various domains such as speech, vision, natural language processing, medical informatics, bioinformatics, data mining and others will be discussed.

CS5341 Computational Photography

Modular Credits: 4

Workload: 2-0-1-0-7

Prerequisite(s): CS4243

Preclusion(s): Nil

Cross-listing(s): Nil

This course covers the exciting new area of "Computational photography", which refers to a broad group of imaging and processing techniques that enhances or extends the capabilities of digital photography to produce new photographs that could not have been taken by a traditional camera. Computational photography promises to change the way we think about photography.

CS5342 Multimedia Computing and Applications

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): CS4341

Preclusion(s): Nil

Cross-listing(s): Nil

This course lays the foundation for graduate students to do research in multimedia systems comprising images, videos, speech, and audio. The module covers the main topics common to multimedia computing applications, i.e., multimedia representation, processing, analysis, and synthesis. By teaching the topics together with the computational tools commonly used in multimedia research, it aims to strike a balance between theoretical considerations and practical applications. Upon completion, the students should be able to understand the foundations of multimedia computing, and apply computational tools to the processing of multimedia data in order to create specific applications.

CS5343 Advanced Computer Animation

Modular Credits: 4

Workload: 2-0-1-5.5-1.5

Prerequisite(s): (CS2010 or CS2020) and MA1101R and MA1521 and CS3241. Good-to-have background: CS4342; CS5240; PC1141; MA1104; CS3244. Good-to have skills: strong in programming; comfortable with math, reading, and public presentation.

Preclusion(s): Nil

Cross-listing(s): Nil

From the covert digital water in Titanic to the mixed real and virtual actors in Avatar, from the arm-controllable Wii games to the completely full-body-play Xbox Kinect games, computer animation technologies have advanced significantly during the past decades, both in the movie and the game industries. This module reveals all the exciting behind-the-scene techniques that make these movies and games possible, including but not limited to motion capture, fluid animation, facial animation, and full-body character animation. This is a project-based course that aims to provide strong foundation on advanced computer animation methods and prepare students for research in animation.

CS5351 The Business of Software

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Undergraduate students in their 4th year can apply. Open to Ph.D. students.

Preclusion(s): Nil

Cross-listing(s): Nil

The software business well exceeds a trillion dollars, covering companies that sell software products as well as corporations that depend primarily on software technology for their business. The course will cover the evolution of software business, and the continuous reshaping of industry. Students will be exposed to market dynamics affecting the birth, growth and transition of these businesses. The course will investigate business strategies followed by these companies. Students will be encouraged to reflect on trends emerging from the integration of innovative technologies and evolving consumer and enterprise needs. There will be special emphasis on Asia-Pacific markets and businesses.

CS6201 Software Reuse

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): (CS3214 or CS3215) and CS4211

Preclusion(s): Nil

Cross-listing(s): Nil

This module is based around reading of papers on software re-engineering and reuse. Topics of programme understanding, reverse engineering, domain modelling, design for and with reuse will be covered. The objective is to familiarise students with principles, practicalities and key research issues in areas of software re-engineering and reuse. The business context of re-engineering and reuse are emphasised. Issues of implementing reuse in a company are discussed, and relations between software re-engineering methods and software reuse are examined.

CS6202 Advanced Topics in Programming Languages

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3211 or CS3212 or CS4212

Preclusion(s): Nil

Cross-listing(s): Nil

This module discusses the contemporary concepts in the design and implementation of major programming languages and systems. It aims to provide students with advanced technical knowledge in evaluating, designing, and implementing an efficient and expressive programming language/system. Topics are selected from a group of contemporary issues that have substantial impact on the development of programming languages/systems, either in terms of performance efficiency or programming expressivity. These include, but are not restricted to, computational models, programme semantics, concurrency theory, garbage collection techniques, programme analysis, type inference, programme calculation and transformation, run-time profiling, implementation models, meta-programming.

CS6203 Advanced Topics in Database Systems

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3223

Preclusion(s): Nil

Cross-listing(s): Nil

This module covers the topics in database management systems with current research, and industrial interests and importance. Examples of topics include multimedia data management, object-oriented database technology, data warehousing and data mining, integration of heterogeneous and legacy systems.

CS6204 Advanced Topics in Networking

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): CS5229 or permission from lecturer

Preclusion(s): Nil

Cross-listing(s): Nil

This graduate level course covers a broad range of the latest developments in computer networking and telecommunications in terms of new techniques and technologies, trends, open research issues and some related new principles and approaches in networking. Selected topics covered via class lectures and assigned readings include developments in the past three years. Upon completion of this course, the student will be able to understand the latest issues and proposed solutions in networking, and acquire the skills and methodology for identifying research problems. This course will help prepare students towards a research career in networking.

CS6205 Advanced Modelling & Simulation

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3232

Preclusion(s): Nil

Cross-listing(s): Nil

The aim of this course is to provide students with the ability to model, simulate and analyse complex systems in a reasonable time. This course is divided into three parts and covers advanced techniques in simulation model design, model execution, and model analysis. A selection of model design techniques such as conceptual models, declarative models, functional models, constraint models, and multi-models will be discussed. Model execution techniques include discussion of serial and parallel discrete-event simulation algorithms. For model analysis, topics include input-output analysis, variance reduction techniques and experimental design.

CS6206 Advanced Topics in HCI

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3240

Preclusion(s): Nil

Cross-listing(s): Nil

This module covers advanced topics in human computer interaction that are of current research or application interest. Its aim is to examine both the theoretical bases that underlie the design of interfaces and advanced technologies for human computer interactions. A wide range of topics may be covered, including psychological theories, organisational behaviour, virtual reality, augmented reality, and computer-supported cooperative work. The module illustrates where and when the theories are applicable, demonstrates the solutions using a combination of scientific theory understanding and engineering modelling. It also illustrates advanced technologies that form part of the solutions.

CS6207 Advanced Natural Language Processing

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS4248

Preclusion(s): Nil

Cross-listing(s): Nil

The module aims to prepare students to embark on research in natural language processing (NLP). At the end of the course, the students will have experience in reading and critiquing research papers, and will have undertaken a substantial project on some aspects of NLP research. Topics covered include: Statistical parsing, Word sense disambiguation, SENSEVAL, co-reference resolution, machine translation, question answering.

CS6208 Advanced Topics in AI

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3243

Preclusion(s): Nil

Cross-listing(s): Nil

This module covers advanced topics in artificial intelligence that are of current research or application interest. A wide range of topics may be covered including soft computing (fuzzy logic, genetic algorithms, etc.), data mining, machine learning, image and video processing, artificial life, robotics, etc. The exact topics to be taught will depend on the lecturers teaching the module.

CS6209 Topics in Cryptography

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The objective of this module is to provide a systematic treatment to cryptography techniques. Topics covered include: mathematical foundations; information theory; classical cryptographic systems: substitution cipher, shift cipher, affine cipher, hill ciphers, permutation cipher, etc.; design and analysis of block ciphers; pseudorandom numbers and sequences; design and analysis of stream cipher cryptosystems; identification and entity authentication; key management techniques; Rabin public-key encryption; McEliece publickey encryption; signature schemes: RSA, ElGamal, and digital signature standard; design and analysis of hash functions; cryptographic protocols; and efficient implementations.

CS6210 The Art of Computer Science Research

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): CS3230 Preclusion(s): Nil

Cross-listing(s): Nil

This module aims to provide the meta-skills for research in computer science. How does one discover great research problems? What are the good strategies for solving research problems? How does one write papers or give presentations with great impact? Students will seek answers to these questions by critically examining and assessing successful and less successful examples of research.

CS6212 Topics in Media

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Variable, depending on the choice of topics or departmental approval.

Preclusion(s): Nil

Cross-listing(s): Nil

There is a surge in both industrial interest and the advancement of media technology. This course aims to bring in the latest advanced development in media technology to the postgraduates.

CS6213 Topics in Distributed Computing

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3211 or CS4231

Preclusion(s): Nil

Cross-listing(s): Nil

Since computer networks and clusters are becoming more and more ubiquitous, the use of parallelism is no longer restricted to privilege access to powerful supercomputers. The main aim of this module is to provide an in-depth study of some of the recent advances in distributed computing. Topics covered include HLA (High Level Architecture) distributed simulation, performance issues in distributed systems, scalable web servers and some issues in peer-to-peer distributed computing. This is a project-based module and students will have extensive hands-on experience using the software tools we have developed in our research.

CS6220 Advanced Topics in Data Mining

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS5228

Preclusion(s): Nil

Cross-listing(s): Nil

With the rapid advances of computer and internet technologies, a large amount of data accumulates. Discovering knowledge from the data will give us a competitive advantage. The process of knowledge discovery involves preprocessing the data, mining or discovering patterns from the data, and post-processing the discovered patterns. In this course, we will review and examine the present techniques and the theories behind them and explore new and improved techniques for real world knowledge discovery applications. The course is designed to encourage active discussion, creative thinking, and hands-on project development.

CS6221 Modelling and Analysis Techniques in Systems Biology

Modular Credits: 4

Workload: 2-1-0-2-5

Prerequisite(s): MA1521 or its equivalent.

Preclusion(s): Nil

Cross-listing(s): Nil

This course provides an introduction to modelling and analysis techniques relevant to systems biology with a focus on the dynamics of biochemical networks. We shall introduce models such as ordinary differential equations, Petri nets, Markov chains and dynamic Bayesian networks and show how they can be used to describe and analyse metabolic, signaling and gene regulatory networks. Self-study, tool-based modelling assignments and guest lectures by biologists will also be key components of the course. The core lectures will be largely self-contained and students with diverse backgrounds are expected and welcome to attend.

CS6222 Special Topics in Computational Biology

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): CS2220

Preclusion(s): Nil

Cross-listing(s): Nil

This lecture/seminar-based module introduces some biological investigations enabled by the latest experimental technologies in biology. We focus on the role of computing in helping biologists with these investigations. Students are expected to attend lectures, give seminars, and do projects. The seminars require the students to read papers related to the selected biological investigations, the enabling experimental technologies, and associated computational solutions. For the projects, students need to develop some methods/algorithms, integrate existing tools, or enhance existing tools with new functions.

CS6230 Topics in Information Security

Modular Credits: 4

Workload: 2-0-0-3-5

Prerequisite(s): CS4233 or CS5231 or CS6209

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims to prepare graduate students for research and development in system and information security. The module will

be conducted by staff and/or industrial experts working in the field of information security. A wide range of topics may be covered, with emphasis on the application of cryptographic techniques to secure emerging applications, systems, and networks. The exact topics to be taught will depend on the lecturers teaching the module. The module will involve a combination of lectures, term projects and student presentations. Target students should have basic knowledge of cryptography, operating systems and networks.

CS6234 Advanced Algorithms

Modular credits: 4

Workload: 2-0-0-5-3

Prerequisite(s): CS5234

Preclusion(s): Nil

Cross-listing(s): Nil

This module is aimed at graduate students who are doing or intend to do advanced research in algorithm design and analysis in all areas of computer science. The module covers advanced material on combinatorial and graph algorithms with emphasis on efficient algorithms, and explores their use in a variety of application areas. Topics covered include, but are not restricted to, linear programming, graph matching and network flows, approximation algorithms, randomised algorithms, online algorithms, local search algorithms, algorithms for large datasets. The module will be a seminar-based module that will expose students to current research in these areas.

CS6240 Multimedia Analysis

Modular Credits: 4

Workload: 3-0-0-4-3

Prerequisite(s): CS4243 or CS5240

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims to provide a comprehensive and rigorous treatment of the main approaches in multimedia (document, image, video, and graphics) analysis. Three main themes are covered: (i) representation and modelling of multimedia entities using various modelling approaches, (ii) matching of a model with an input entity, and (iii) derivation of a model from sample entities. It focuses on the non vector-space approach, which complements the vector-space approach to multimedia analysis.

CS6241 Advanced Topics in Computer Graphics

Modular Credits: 4

Workload: 3-0-0-3-4

Preclusion(s): Nil

Cross-listing(s): Nil

Prerequisite(s): Variable, depending on the choice of topics or departmental approval.

This course aims to familiarise graduate students with the ongoing research works in interactive 3D graphics. Topics covered may include: interactive technologies, graphics data structures (shape representation), image-based modelling and rendering, creation of artistic artefacts, viewing large models, and interactive modelling.

CS6242 Digital Libraries

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): CS3245 and CS3246 or their equivalent

Preclusion(s): Nil

Cross-listing(s): Nil

This module is targeted to graduate students of computer science and information systems wishing to understand the issues in building, using and maintaining large volumes of knowledge in digital libraries. Fundamentals of modern information retrieval is assumed. The course will focus on how such information retrieval technology operationalises traditional information finding skills of the librarian/cataloguer/

archivist, organised around 5S framework for digital library education. Areas within digital libraries that will be covered include collection development, knowledge organisation, DL architecture, user behavior, services, preservation, management and evaluation and DL education and research. Students will round out their knowledge with case studies of how different disciplines (e.g. music, arts, medicine and law) impose different search, usability and maintenance requirements on the digital library.

CS6270 Virtual Machines

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): CS2106 and (CS3220 or CS4223)

Preclusion(s): Nil

Cross-listing(s): Nil

Virtual machines (VMs) are increasingly being seen as a convenient vehicle for managing heterogeneous resources (e.g. server consolidation) and for solving problems related to mobile code and security. Commercial VMs from VMware and language-level VMs such as the Java Virtual Machine and Microsoft's .NET framework have become highly popular. This module will summarise the state-of-the-art in virtualisation technology and discuss techniques for designing and implementing modern VMs, hardware-level,

operating system-level and language-level VMs, CPU virtualisation concepts, paravirtualisation and binary translation techniques, techniques for memory and input/output virtualisation, and applications of VMs in solving problems related to security and software distribution.

CS6280 Topics in Computer Science I

Modular Credits: 4

Workload: 3-0-0-3-4

Preclusion(s): Nil

Cross-listing(s): Nil

Prerequisite(s): Background in modelling and analysis of reactive systems. Basic knowledge of algorithms. It will be helpful but not necessary to have some background in biology.

The topics covered will include: models of computation for signalling pathways, parameter estimation techniques, models of gene regulatory networks, technologies for producing high throughput experimental data, analysis techniques and simulation tools relevant for computational systems biology.

CS6281 Topics in Computer Science II

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Variable, depending on the choice of topics or departmental approval.

Preclusion(s): Nil

Cross-listing(s): Nil

Topics will be of an advanced computer science nature and will be selected by the Department.

CS6282 Topics in Computer Science III

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Variable, depending on the choice of topics or departmental approval.

Preclusion(s): Variable, depending on the choice of topics or departmental approval.

Cross-listing(s): Nil

Topics will be of an advanced computer science nature and will be selected by the Department. Refer to the course website for details.

CS6283 Topics in Computer Science IV

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Variable, depending on the choice of topics or departmental approval.

Preclusion(s): Variable, depending on the choice of topics or departmental approval.

Cross-listing(s): Nil

Topics will be of an advanced computer science nature and will be selected by the Department. Refer to the course website for details.

CS6284 Topics in Computer Science V

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Variable, depending on the choice of topics or departmental approval.

Preclusion(s): Variable, depending on the choice of topics or departmental approval.

Cross-listing(s): Nil

Topics will be of an advanced computer science nature and will be selected by the Department. Refer to the course website for details.

CS6285 Topics in Computer Science VI

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Variable, depending on the choice of topics or departmental approval.

Preclusion(s): Variable, depending on the choice of topics or departmental approval.

Cross-listing(s): Nil

Topics will be of an advanced computer science nature and will be selected by the Department. Refer to the course website for details.

CS6880 Advanced Topics in Software Engineering

Modular Credits: 4

Workload: 3-0-0-4-3

Prerequisite(s): CS2103

Preclusion(s): Nil

Cross-listing(s): Nil

This module discusses contemporary concepts in software engineering, ranging from domain analysis, requirement analysis and software architectures; formal methods, analysis, design and implementation. It aims to provide students with advanced technical and managerial knowledge in evaluating, designing, and implementing big-scale software. These include: Specialised methods for specific application domains (such as embedded systems or Web systems), in-depth study of software engineering sub-disciplines (such as testing or maintenance), as well as the issues of programming language support for software engineering. The module also provides students the opportunity to understand the methodology involved in software-engineering research.

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IS1103 Computing and Society

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): Nil

Preclusion(s): CS1105/A

Cross-listing(s): Nil

Students will explore the interactions and impact of computing and information technologies on social systems. They will examine how technological paradigms transform industries, organisations and individuals, and vice versa; how policies and social norms are developed as they relate to technology use; and investigate the emerging controversies surrounding the regulation of technology in society. Emphasis is placed on establishing an in-depth understanding of the professional and ethical responsibilities of computing professionals, and developing an ability to analyse the impact of computing technologies on a local and global scale. Historical and contemporary studies, cases and examples will be used extensively.

IS1105 Strategic IT Applications

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): Nil

Preclusion(s): CS2250

Cross-listing(s): Nil

This foundation course develops an understanding of the role of IT in the value chain, and the ever-changing competitive arena of information age. The focus is on the following topics: the nature and characteristics of information technology (IT), the strategic roles of IT for organisational improvements in operations, planning and decision making. The course is directed toward future IT specialists, consultants, and managers who must have a basic understanding of information technologies; including identifying strategic opportunities for Information Systems (IS) deployment, managing IT resources, and evaluating IT investments.

IS1112 E-Business Essentials

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This foundation course aims to provide a broad introduction to the nature of e-business activities from practical, technical, business and strategic perspectives. It will provide students with a comprehensive understanding of the technical elements that facilitate the development of the Internet and e-commerce, and the principles and concepts underlying the use of these technologies to facilitate e-business operations. Topics covered include: the evolution of e-business from operational, technical and strategic perspectives, basic computer networking and database concepts, website architecture and multimedia on the Internet, internet technologies, services and applications (e.g., social networking, telephony, P2P, etc), and emerging standards in e-business.

IS2102 Requirements Analysis and Design

Modular Credits: 4

Workload: 2-1-0-2-5

Prerequisite(s): CS1010 or CS1101 or CS1101S

Preclusion(s): Nil

Cross-listing(s): Nil

Business requirements analysis is the process of discovering requirements, analyzing requirements for incompleteness, inconsistency, relevance and practicality, and negotiating the final requirements for the systems. Whether the computer systems developed are what users want depends on how well requirements are captured at the earlier stage of system development. This

module teaches Business Requirements Analysis in the Unified Process, particularly, the process of requirements elicitation, analyses, documentation, and communication. This module also teaches transition from business requirement analysis to design, UML (Unified Modelling Language) and Use Case Modelling.

IS2104 Software Team Dynamics

Modular Credits: 4

Workload: 3-0-0-4-3

Prerequisite(s): Students can only take this module after completing 40 MCs

Preclusion(s): Nil

Cross-listing(s): Nil

This course introduces students to the fundamentals of teams and working in teams. Emphasis is placed on team dynamics in the software environment. Students will learn about different types of software teams, the challenges of working in such teams and how to work and manage such teams effectively. A variety of instructional methods including lectures, in-class group activities, discussions and debates, videos and fieldwork will be used to facilitate teaching of the course.

IS2103 Enterprise Systems Development Concepts

Modular Credits: 4

Workload: 2-0-1-3-4

Prerequisite(s): CS1020 or CS1102 or CS1102C or CS1102S

Preclusion(s): CS2261

Cross-listing(s): Nil

The focus of this module is to train students to be conversant in the technologies and approaches to developing software systems at the enterprise level. Technologies covered include J2EE (Java 2 Enterprise Edition) and .NET (from Microsoft). Emphasis will be placed on teaching students J2EE standard specification. Major topics covered include Business Information Systems; Enterprise Platforms; Distributed Computing Concepts; JavaBeans; Servlets and Java Server Pages; Model, View, Controller model; Enterprise JavaBeans; XML, Web Services, Deployment; Persistence Management and Security.

IS2150 E-Business Design and Implementation

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): (CS1020 or CS1102 or CS1102S) and IS1112

Preclusion(s): Nil

Cross-listing(s): Nil

This module aims to train students to be conversant in the technologies, approaches, principles and issues in designing effective e-commerce and e-business systems. Major topics include: J2EE and .NET for e-commerce, scripting languages (Javascript/JSP/ASP/PHP/Perl), development frameworks (Flex, AJAX, servlets), database design and management for the internet, tracking and analysis of customers, payment services/verification, implementing security, XML, inventory/order/shipping management services and systems, planning, designing and deploying web services, and operational considerations and technical tradeoffs.

ISS3101 Management of Information Systems

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS2250 or (IS1103 and IS1105)

Preclusion(s): CS3253

Cross-listing(s): Nil

The course covers the essentials in management of information systems in an organisational setting. Students will gain an understanding of the managerial issues in the development and operation of information systems. The main topics include: information systems planning, management of systems development and maintenance, implementation management, end-user computing, data centre operations, information systems control and evaluation, acquisition of IS resources and management of IS personnel. Case studies will be used to illustrate the issues and solutions.

IS3102 Information Systems Development Project

Modular Credits: 8

Workload: 1-1-0-10-8

Prerequisite(s): CS2261 or IS2103 (applicable to intakes from AY2005/06 to AY2007/08) or [(CS2261 or IS2103) and (CS2301 or IS2101)] (applicable to intakes from AY2008/09 onwards)

Preclusion(s): CS3214

Cross-listing(s): UIS3954R

Students are required to work (in groups) through a complete Systems Development Life Cycle to develop a business information system based on techniques and tools taught in CS2103 or IS2103 (old code: CS2261). IS3102 can be viewed as a large-scale practical module of CS2103 or IS2103. They will also sharpen communication skills through close team interactions, consultations, and formal presentations. Emphasis will be placed on requirement analysis, system design, user interface design, database design

and implementation efficiency. Students will be assessed based on their understanding and ability to apply software engineering knowledge on a real-life application system.

IS3150 Digital and New Media Marketing

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 60 MCs and IS1105 and IS1112

Preclusion(s): Nil

Cross-listing(s): Nil

This module introduces students to the principles and practice of marketing management of IT products and services in the digital economy, and the application of computer decision tools and techniques for marketing on new interactive media, such as the Internet and mobile phone platforms. The main topics of this module are: the concept of marketing, marketing environment in the digital economy, marketing research, buyer behaviour, IT market analysis, segmentation, targeting and positioning, IT product design, pricing, advertising and promotion, marketing channel and campaign management in new media platforms, etc. Cases and examples will be drawn from the high-tech IT industries.

IS3220 Service Science

Modular Credits: 4

Workload: 3-0-0-4-3

Prerequisite(s): Pass 60 MCs and [CS2250 or (IS1103 and IS1105)]

Preclusion(s): CS3361

Cross-listing(s): Nil

This module aims at providing an interdisciplinary educational foundation for students in Service Science. Service Science is the application of scientific, management, and engineering disciplines to the tasks (services) that one organisation beneficially performs for itself and with another. The module will cover the definition and goals of services, creation, operation, marketing and delivery of services, and the role of IT service systems. It will discuss how IT-enabled services impact an organisation and the external environment.

IS3221 Enterprise Resource Planning Systems

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): CS2250 or (IS1103 and IS1105)

Preclusion(s): CS3264

Cross-listing(s): Nil

Business resources include employees, business processes, procedures, organisational structure, and computer systems. The efficiency and effectiveness of an organisation in carrying out its business can be enhanced if managers and employees are given the support to plan, monitor and control the business. Enterprise Resource Planning (ERP) supports the use of all resources in an organisation. In this course, students will learn the rationale for having ERP, ERP functionality (such as manufacturing, finance, distribution and human resource management), ERP and information technology, ERP systems and ERP implementation (planning, product selection, implementation and optimisation).

IS3222 IT and Customer Relationship Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 60 MCs and {CS2250 or (IS1103 and IS1105)}

Preclusion(s): CS4266

Cross-listing(s): Nil

CRM (Customer Relationship Management) systems are the cornerstone of enterprise systems to manage customer relationships and equity in business organisations. This module aims to introduce concepts in CRM and in the application, implementation and management of CRM technologies. Topics covered include CRM strategy in B2C and B2B contexts, integrating IS/IT strategy with CRM objectives, economic returns from CRM, information privacy in CRM, CRM data warehouse and information structure, data mining techniques for CRM, CRM systems and technologies, CRM system implementation in B2C/B2B contexts, CRM system vendor selection and evaluation. Instructional methods will include lectures, tutorials, case studies, and/or project-based learning.

IS3223 IT and Supply Chain Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 60 MCs and [CS2250 or (IS1103 and IS1105)]

Preclusion(s): CS4267

Cross-listing(s): Nil

This course focuses on the understanding of the role of IT in enabling effective supply chain strategies in the global economy. Particularly, it focuses on how to plan the integration of supply chain components into a coordinated system using IT. Besides the basic concepts, students will be exposed to the role of IT in risk pooling and inventory placement, integrated planning and

collaboration, and information sharing in supply chain management.

IS3230 Principles of Information Security

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 60 MCs and [(IS1103 or CS1105) and (CS2105 or IS1112)]

Preclusion(s): CS3254

Cross-listing(s): Nil

With the prevalent use of computers and the internet in the modern organisation, threats and attacks on information systems are also on the rise. This module introduces the principles of information security, to prepare students for their future roles as IS professionals. Students will understand that protecting organisational information requires a holistic approach which includes policy, technology and education. The focus of the module is on principles and concepts, rather than hands-on skills.

IS3240 Economics of E-Business

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 60 MCs and [EC1101 or EC1101E or EC1301 or EC1310 or EC1311 or GCE 'A' Level Economics or BSP1005]

Preclusion(s): CS3265

Cross-listing(s): Nil

We are living in a "New Economy" with e-business. E-Business means not only "selling products electronically" but also the digitalisation of many conventional business processes: financing, advertising, and managing human resources. These process-related changes significantly impact intra-business organisation, business-to-business relationships, and business-to-consumer interactions. As technology advances breathlessly, the ideas, concepts, and models of economic principles need to be applied carefully. The economic analyses, such as differential pricing, bundling, signalling, licensing, lock-in, or network effects can be directly applied to the e-business economy. This course aims to give students economic insights to understand e-business and to make better decisions in e-business.

IS3241 Enterprise Social Systems

Modular Credits: 4

Workload: 3-0-0-2-5

Prerequisite(s): Pass 60 MCs and [CS2250 or (IS1103 and IS1105)]

Preclusion(s): CS3267

Cross-listing(s): Nil

This is an advanced course on the management and technological issues associated with new trends in social systems. The primary focus of the course will be on enterprise social systems that leverage social networks. Such social systems involve creating social spaces where people can collaborate online, get advice from trusted individuals and find goods/services through platform-mediated networks. This course will also emphasise the powerful role that social computing technologies (e.g., social networking sites, blogs, wikis, recommendation systems, social bookmarking, etc.) are playing and a comprehensive set of business models for implementing these strategies.

IS3242 Software Quality Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 60 MCs and [IS1105 or CS2250]

Preclusion(s): Nil

Cross-listing(s): Nil

As more business operations are dependent on information systems today, the importance of software quality is ever growing. It is also imperative for IT vendors to meet the increasing demand for high quality IT service and software products by customers. This module focuses on how to apply quality management concepts and practices to the development and maintenance of software. Particularly, students will learn about various quality metrics, models, and standards specific to the software domain.

IS3243 Technology Strategy and Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 60 MCs and [CS2250 or IS1105]

Preclusion(s): CS3251

Cross-listing(s): Nil

Students will understand the theory and practice of business strategy as applied to technology-oriented (and in particular, IT-oriented) products and services. The module provides students with a broad and in-depth understanding of the theory and practice of technology strategy and management. These will be applied to information technology-related products and services. Students will also understand the life cycle and product development process of technological innovations. Case studies form a major part of this module.

IS3250 Health Informatics

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): Pass 60 MCs

Preclusion(s): Nil

Cross-listing(s): Nil

The goal of this module is to provide students with an introduction to the many facets of IT applications in healthcare. With the increasing use of IT in the healthcare landscape, there has been a steady growth of demands for IT systems and innovations to streamline healthcare practice and to provide for quality patient care. Lectures will cover IT systems in healthcare settings, decision-making in patient care, standards and interoperability issues, patient data privacy and security and challenges associated with IT implementation in healthcare enterprises. The module is useful for students with the view to an IT career in healthcare.

IS3260 Gamification

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 60 MCs and (CS1020 Data Structures and Algorithms I or its equivalent)

Preclusion(s): Nil

Cross-listing(s): Nil

Gamification is the use of game play thinking and mechanics to engage audiences. For the younger generation, gaming has become part of their lives, and thus it is desirable to use games to engage them at work and as part of marketing strategies. The goal of this module is to provide students with an introduction to gamification and funware. Lectures will cover the various game elements, their psychological impact on people and ways to deploy them. Students will also work on group projects to learn to deploy gamification.

IS4100 IT Project Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 80 MCs and [CS2250 or (IS1103 and IS1105)] and (CS2261 or IS2103)

Preclusion(s): CS4254 or CS5212 or IS5110

Cross-listing(s): Nil

This module focuses on the management of IS projects. Various managerial issues pertaining to the evaluation and selection of information systems projects, choice of project organisation, planning, scheduling and budgeting of project activities, and basic principles in control and project auditing will be covered. The students will also learn how to use practical techniques and tools, such as network models (PERT/CPM), simulation, and state-of-the-art project management software, in scheduling project activities. This module serves as a good introduction to information systems project management for students who may participate in coordinating and managing large-scale information systems projects.

IS4102 E-Business Capstone Project

Modular Credits: 8

Workload: 3-0-0-9-8

Prerequisite(s): Pass 80 MCs and [CS3240, IS2150, IS3230 and IS3150]

Preclusion(s): Nil

Cross-listing(s): Nil

In this module, students are required to complete a Systems Development Life Cycle to develop an e-business system based on principles taught in previous modules. This project can be viewed as a large-scale practical module. Emphasis will be placed on system design, user-interface design, database design, security strategy, and performance. Students will appreciate differences in the scalability, usability, performance and security aspects. They will also sharpen communication skills through close team interactions, consultations, and formal presentations. Students will also develop a comprehensive understanding of the issues of e-business implementation from an enterprise architecture standpoint.

IS4150 Mobile and Ubiquitous Commerce

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 80 MCs and IS2150

Preclusion(s): Nil

Cross-listing(s): Nil

In this module, students will develop an appreciation for the strategic, operational, and technical issues for e-commerce in the emerging domains of mobile and ubiquitous computing. It provides students with an understanding of the theory and practice of e-business management and systems development in these domain areas. The module covers concepts such as frameworks for mobile commerce, enabling business processes and models, as well as technologies for enabling commerce on non-traditional computing platforms. Students will learn to design and develop e-business applications on these platforms to meet constantly changing business needs. Case studies form a major part of this module.

IS4202 Global Virtual Project

Modular Credits: 4

Workload: 3-0-0-7-0

Prerequisite(s): Pass 80 MCs and IS2104

Preclusion(s): Nil

Cross-listing(s): Nil

With the increasing globalisation of businesses and the availability of sophisticated IT tools to communicate, global virtual teams are becoming commonplace in organisations. Global Virtual Project is a project-based module, in which students from different universities from around the world will work together on projects that are global in nature. Apart from background materials being provided, the major part of the module will be constituted by the project.

IS4203 IT Adoption and Change Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 80 MCs and [IS3101 or CS3253]

Preclusion(s): Nil

Cross-listing(s): Nil

This course introduces students to the fundamentals of managing change and adoption associated with the introduction and implementation of new systems and technologies. Emphasis will be placed on the understanding and effective management of end-user reactions to the adoption and use of new systems and technologies. Topics to be covered include IT adoption and use process, dealing with user resistance, effective change vision, short and long-term change, outcomes evaluation, and preventing change deterioration.

IS4224 Service Systems

Modular Credits: 4

Workload: 3-0-0-4-3

Prerequisite(s): Pass 80 MCs and [CS3361 or IS3220]

Preclusion(s): CS4361

Cross-listing(s): Nil

This module aims at introducing students to the systems approach of analysing service systems. It will cover the fundamentals of systems thinking for business services, and extend to large-scale IT-integrated services. Students will learn about holistic social-technical systems, considering all the important factors, such as IT, business organisation, user characteristics and different cultural environments. Case studies form an integral component of this module, to enhance student knowledge and application skills.

IS4225 Strategic IS Planning

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 80 MCs and [CS2250 or (IS1103 and IS1105)]

Preclusion(s): CS4251; Arts and social sciences students reading CNM as a subject/concentration are not allowed to read this module as CFM/ULR-Breadth.

Cross-listing(s): Nil

This module covers strategic planning to link information needs and technology support to organisational objectives. The module content includes: IT effects on industries, markets, and organisations; how organisations can use IT to gain competitive advantage; evaluation of business strategy (plans) and IS strategy (plans); and management of aligning business strategy (plans) and IS strategy (plans). The module will focus on organisational performance (efficiency, effectiveness, and competitiveness), the use of IT as a means to enhance organisational performance (not an end in itself), and creative and analytical frameworks and methodologies.

IS4226 IT Outsourcing and Offshoring Management

Modular Credits: 4

Workload: 3-0-0-5-2

Prerequisite(s): Pass 80 MCs and [CS2250 or (IS1103 and IS1105)]

Preclusion(s): CS4255

Cross-listing(s): Nil

The module focuses on issues faced when IT organisations engage in outsourcing, offshoring and internationalisation. It also provides students with the theoretical framework and tools to identify core IT capabilities and analyse relevant activities for outsourcing and offshoring. Besides equipping students with the fundamentals and theoretical perspectives of these phenomena, the course will also expose them to practical issues ranging from the managerial to economical, from cultural to political, from methodological to regulatory. Students will graduate with a better appreciation of the IT industry in both developing and developed countries.

IS4227 Enterprise Service Oriented Architecture

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisites: Pass 80 MCs and [CS3361 or IS3220]

Preclusion(s): CS4258

Cross-listing(s): Nil

This module provides students with an overview of service-oriented architecture (SOA). The key topics covered include SOA concepts and principles, SOA architecture and design considerations, and SOA relationship with enterprise capabilities. Key concepts from web services, that are relevant to SOA, will be covered with an emphasis on how these ideas may enhance the performance of enterprises. Approaches to service-oriented software development (including reliability and security considerations) will also be included. Overall, this module equips students with the necessary knowledge and skills to implement SOA in enterprises.

IS4231 Information Security Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisites: Pass 80 MCs and IS3230

Preclusion(s): CS3254

Cross-listing(s): Nil

The main focus of this module is the managerial aspects of information security. This module prepares the students for their future roles as IS managers or IS security professionals. Through this module, students will appreciate the challenges of managing information security in the modern business organisation. Topics include risk management, security policies and programmes, managing the security function, and planning for continuity.

IS4232 Topics in Information Security Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisites: Pass 80 MCs and IS3230

Preclusion(s): Nil

Cross-listing(s): Nil

As information security is a fast-developing field, this module will cater to recent or specialised topics in information security. The content is expected to change from year to year. Possible topics include incident management and business continuity, digital forensics, and e-commerce and m-commerce security.

IS4233 Legal Aspects of Information Technology

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 80 MCs and [CS2250 or (IS1103 or IS1105)]

Preclusion(s): CS4259

Cross-listing(s): Nil

This module is a study of laws that have an impact on the IT industry. Among the topics to be addressed are the intellectual property of software, database, and multimedia entertainment contents, data privacy, information security, and electronic commerce law. The goal of the course is to provide basic background in these issues for non-lawyers. The course enables IT professionals to better handle their legal resources and better understand their commercial opportunities. Real-world examples from the text and current events will be used to demonstrate the applicability of the law in IT industries.

IS4234 Control and Audit of Information Systems

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 80 MCs and [CS3254 or IS4231]

Preclusion(s): CS4252

Cross-listing(s): Nil

The aim of this module is to provide an in-depth study of information systems security in business organisations. This module provides an opportunity for students to examine the design of security control, and auditing processes and procedures of information systems from a management perspective. The course will cover the economics of security, principles of management and application control, evidence gathering and evaluation, auditing procedures and techniques. The emphasis of this course is on managerial and business issues rather than technical issues, such as encryption algorithms and virus-manipulation.

IS4240 Business Intelligence Systems

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisites: Pass 80 MCs and [(CS2102 or CS2102S) and [(CS2250 or (IS1103 and IS1105)] and (ST1131 or ST2334)]

Preclusion(s): CS4256

Cross-listing(s): Nil

Business Intelligence (BI) is the application of database and machine learning technologies in business. It enables organisations to improve decision making, enhance its strategic position, and maintain competitive advantage. This module will introduce students to

the essentials of BI, placing emphasis on database and machine learning technologies for building effective BI Systems. Students will learn about data warehousing and data visualisation, as well as the various tools that can be employed for intelligent business decision making. BI cases will be used to highlight the issues and problems encountered by organisations as they develop and implement BI systems.

IS4243 Information Systems Consulting

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 80 MCs and [CS2250 or (IS1103 and IS1105)]

Preclusion(s): CS4253

Cross-listing(s): Nil

The aims and objectives are:

- (i) to provide an overview of Information Systems (IS) consulting and to develop a more specific understanding of the practice;
- (ii) to provide students with the knowledge of management and IS consulting practices; and
- (iii) to give students the opportunity to be involved in a field consulting project.

IS4260 E-Commerce Business Models

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Pass 80 MCs and [CS2250 or (IS1103 and IS1105)]

Preclusion(s): CS4260

Cross-listing(s): Nil

As the fastest-growing facet of the Internet, electronic commerce offers functionality and new ways of doing business that no company can afford to ignore. The basis for moving to an electronic commerce platform is a belief that electronic markets have the potential to be more efficient in developing new information goods and services. In addition, electronic commerce also offers companies new ways of linking trading partners and global customers. Students taking this course learn the characteristics of various b-webs such as agora, aggregation, value chain and alliances, and have opportunities to do research in their areas of interest.

IS5001 Foundation in IS Research Methodologies

Modular Credits: 4

Workload: 0-0-0-0-10

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The purpose of this module is to test students on essential knowledge of IS research methodologies. The students will be tested on their understanding in topics such as research design, sampling, measurement, data collection methodology (case study, survey, experimentation, etc.), theoretical and empirical analysis, and basic statistical methods.

IS5002 Foundation in Management of IS

Modular Credits: 4

Workload: 0-0-0-0-10

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The purpose of this module is to test students on essential knowledge in the management of information systems. The students will be tested on classical MIS issues such as the contribution of IS to decision making, IS diffusion and implementation, IS strategy, and IS and business processes. If a particular student wants to be tested on specific MIS knowledge outside of this list (e.g., user psychology of IS, system development methodology, economic contributions of IS), he/she can propose a list of topics to the graduate division committee. The request will then be reviewed and approved on a case-by-case basis.

IS5110 Software Project Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This module examines the managerial aspects of the software production process: from its initial feasibility phase to its maintenance phase. It covers topics such as feasibility studies, cost estimation and control, quality and operational integrity reviews, project scheduling, and control techniques and methods, and productivity and quality metrics. Of particular interest will be the management of cross cultural and cross-border software teams. Students who are certified IT Project Managers will be given credit for this module.

IS5111 Integration of IS and Business

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3251 or IS3243

Preclusion(s): Nil

Cross-listing(s): Nil

This module examines the high-level CEO/CIO perspectives of information systems within the wider scope of the corporation. It covers introduction to information systems in organisations from the general manager's perspective, organisational strategies, finance, operational and other functional objectives, managerial and strategic uses of information systems, overview of enabling technologies, how information systems are developed and managed, long-range planning for information systems investment and employment, study of information technology in Singapore's business environment, and individual and team projects.

IS5112 Knowledge Systems and Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS4251 or IS4225

Preclusion(s): Nil

Cross-listing(s): Nil

Students will get a broad and in-depth understanding of knowledge management, arguably one of the most interesting and powerful IT concepts. Knowledge-intensive organisations are distinguished by their flatter organisation structures and decentralised decision-making processes. Managing these organisations is different from managing traditional organisations. At their core lies a particular knowledge-intensive thinking which concentrates specifically on intellect and reflection. Processes of learning and knowledge management are integrated into the fabric of the organisation. Traditional managerial activities take on new interpretations and meanings, thereby re-conceptualising the role of management. Case studies form a major part of this module.

IS5113 Computer Mediated Communications

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS2250 or (IS1103 and IS1105)

Preclusion(s): Nil

Cross-listing(s): Nil

Computer and communications technologies are changing the ways in which individuals and groups communicate. The impact goes beyond one-to-one communications, to the formation and operation of virtual and semi-virtual groups and work environments. The module examines the mediation of such technologies on verbal and non-verbal communications, feedback, intra-personal communications, inter-personal communications, small group communications, organisational communications, and communication goals. Technologies include basic media such as email, phone, fax, chat board, bulletin board, computer conferencing, and video conferencing. In addition, integrated systems such as group support systems and negotiation support systems will be used for advanced illustration.

IS5114 Information Technology Outsourcing

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): CS3251 or IS3243 or equivalent

Preclusion(s): Nil

Cross-listing(s): Nil

IT outsourcing has a great impact on today's information technology industry. This course will provide an overview of IT outsourcing concepts and practices, and discuss new directions of outsourcing in the context of Internet information management. Topics covered include: vendor management; global outsourcing; outsourcing project management and cross-border knowledge management.

IS5115 Telecoms and International Network

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3260

Preclusion(s): Nil

Cross-listing(s): Nil

Students will gain an understanding of how telecommunications can affect organisations and industries. Rapid advancements in telecommunications technology and the convergence of computing and telecommunications have created unique opportunities for organisations to derive competitive advantage. This module will provide students with a broad and in-depth understanding of the impact of telecommunications technology on organisations. Topics covered include: adoption and diffusion of telecommunications technology, telecommunications technology strategy, telecommunications applications in supply chain management, manufacturing, sales and marketing, inter-organisational networking, convergence, and national or international telecommunications policies.

IS5116 IT and Entrepreneurship

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): (ACC1002 or ACC1002X) and (CS3261 or IS3150)

Preclusion(s): Nil

Cross-listing(s): Nil

This course relies heavily on cases from the IT industry to present the major functional areas and key concepts involved in making successful business decisions. The major objective is to guide students on how to identify and analyse issues in areas such as strategy, new product development, distribution, customer service, and financing. A second objective is to simulate the business management experience by requiring students to communicate and defend their ideas through a sound business plan in a team environment.

IS5117 Electronic Government

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): CS3251 or IS3243

Preclusion(s): Nil

Cross-listing(s): Nil

This course provides current and future public managers with the requisite background to successfully manage e-government projects and government information. The use of information and communication technologies is becoming an indispensable part of government. The goal of the course is to enhance a broad understanding of e-government and information policy. These issues include e-citizenry, e-governance, strategic planning, change management, business process reengineering, design and implementation of information systems, relevant technologies, accessibility, information assurance, and knowledge management with respect to government organisations. Both external applications such as citizen services, and internal processes such as automating document-processing and hiring procedure will be covered.

IS5119 Global Project Coordination

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): [(CS2250 or (IS1103 and IS1105))] and (CS2301 or IS2101)

Preclusion(s): Nil

Cross-listing(s): Nil

Students learn to address the challenges of managing and coordinating a global project to deliver results under tight time constraints. Topics include: approaches for global project management, concepts, frameworks, and diagnostic instruments. Students will form effective global teams with students from other universities, accomplish the objectives established for a global project, and carry out project management in cross-cultural settings. They will work on their projects through various forms of information technology (e.g., telephone, video-conferencing, fax, electronic mail and tools on the World Wide Web). The experience will be valuable to students in an increasingly globalised business environment.

IS5120 Information Technology Policies

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3251 or IS3243

Preclusion(s): Nil

Cross-listing(s): Nil

This course covers policy-making and evaluation of information technology. Students will learn about policy making in organisations as well as at the national level. Topics range from the policy control of information technology within organisations in various industries, the policies peculiar to the IT industry, and the social, educational and economic uses of IT, such as the Internet and E-commerce. Students will learn how policies are made and implemented. They will also learn how to evaluate the long-term impact of these policies.

IS5121 Information Systems Process Engineering

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3253 or IS3101

Preclusion(s): Nil

Cross-listing(s): Nil

Enhancement of organisational performance has been a top priority issue for management. Organisational change projects such as Business Process Redesign for enhancing the performance, however, have been perceived to incur high risk. Information Systems Process Engineering intends to reduce such risk by facilitating a systematic process change method. It integrates process modelling for analysis and design, coordination mechanism, simulation for testing the change, and some engineering guidelines. Computing students will learn the main concepts of Information Systems Process Engineering, demonstrate the application of IS tools to organisational change, and explain the linkage of organisational change to information systems development.

IS5122 Case Studies in Enterprise Systems

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This module examines some of the recent enterprise system management implementation issues taking place in most business organisations. It covers a range of system implementation issues from an information system perspective. Using actual cases, the data collection and analysis methods employed in which these enterprise systems are examined are also discussed. This module is especially useful for research students (M.Sc. and Ph.D.) and part-time students (M.Comp.) who have prior IT industry experience.

IS5123 IT and Supply Chain Management

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): CS3250

Preclusion(s): Nil

Cross-listing(s): Nil

Students learn how to deploy IT to enable and facilitate supply chain management among organisations. Topics include: overview of a supply chain, coordination difficulties, pitfalls and opportunities, tradeoffs between inventory and service, and performance measurement. Students will learn about the role that IT plays in supply chain network design, global supply chain management, the interface between manufacturing and distribution, and supplier management. The module will also explore the approaches (e.g., strategic alliances) and tools for designing and redesigning products and processes for supply chain management, as well as current industry initiatives for IT in supply chain management.

IS5124 E-Commerce Systems and Applications

Modular Credits: 4

Workload: 2-0-0-2-6

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This course aims to provide a substantive overview to the technology and information systems (IS) concepts underlying electronic commerce applications from the technical perspective. Students will develop both conceptual and methodological skills that are critical to conducting excellent e-Commerce projects in their companies. They can also develop interesting research topics or frameworks. The major topics include e-Commerce technologies, digital products, B2C and B2B applications, e-Transformation, and other issues such as security and e-Payment. Target students include both practitioners and research students.

IS5125 System Dynamics

Modular Credits: 4

Workload: 2-0-0-4-4

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This course aims to introduce the methodology of, System Dynamics, and its application for IT strategy analysis and development in the context of IT-driven organisational change. System Dynamics facilitates analysing IT relevant business cases and problems from the systems thinking perspective, formulating and testing IT problems with simulation techniques, and supporting decision making.

IS5151 Information Security Policies

Modular Credits: 4

Workload: 2-0-0-6-2

Prerequisite(s): CS4252 or IS4234

Preclusion(s): Nil

Cross-listing(s): Nil

In this course, students will learn how management, political leadership, and the technical community must work together to make effective strategies and policies. The course will examine how to determine the vulnerabilities and risks. They will be exposed to different competing priorities and factors in the provision of security; legal, cost, and other constraints. From these constraints, they learn to derive different strategies (both technical and procedural) to achieve the desired security objectives.

IS5152 Decision Making Technologies

Modular Credits: 4

Workload: 3-0-0-3-4

Prerequisite(s): ST2334 or ST1131

Preclusion(s): Nil

Cross-listing(s): Nil

Decision making technologies can support decision making in the financial, operational, marketing and other areas. Efforts have been directed at finding new machine learning (ML) techniques for decision making and their possible application in solving practical problems. ML techniques such as artificial neural network methods have been proven to be powerful tools for decision making. Applications include credit rating, bankruptcy analysis, foreign exchange rate predictions and many others. The techniques covered in this course include neural networks for classification/ regression/clustering, genetic algorithm for optimisation, decision tree methods, support vector machine and data mining.

IS6000 Qualifying Examination in IS

Modular Credits: 4

Workload: 20 hours per week

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This module evaluates students on essential knowledge of IS research methodologies and application domains of management information systems. Students will be tested on their ability to integrate method (e.g., survey, experiment, qualitative, technical, or econometrics) and domain (e.g., knowledge management, electronic commerce) knowledge towards designing studies to investigate current phenomena in IS.

IS6001 Qualitative Methods for IS Research

Modular Credits: 4

Workload: 2-0-0-3-5

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This module will provide an overview of qualitative IS research philosophies and methods. Methods that will be covered include action research, case study research, ethnographic research, and grounded theory. Apart from data collection procedures (interviews, focus groups, participant observation, and secondary data), the spectrum of data analysis techniques that will be discussed include hermeneutics, semiotics, narrative analysis, and protocol analysis. The course will conclude by guiding students to write up their results for publication.

IS6002 Quantitative Methods for IS Research

Modular Credits: 4

Workload: 2-0-0-3-5

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This module will cover the essential methods in quantitative IS research. It will start with a discussion of measures and data collection. It will then go more in-depth into the experimental methods, design, and analysis using ANOVA and variants. Subsequently, survey design and analysis including regression, moderation, mediation, factor analysis, and structural equation modelling will be covered. Secondary data analysis using discriminant analysis, logistic regression, Bayesian network, clustering, and basic text processing will also be discussed. The course will conclude with discussion on the review and critiquing of quantitative research.

IS6003 Contemporary Theories for IS Research

Modular Credits: 4

Workload: 2-0-0-3-5

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

The main objective of this course is to familiarise graduate students with the main theories in IS and to prepare them to develop new theories in their research. In particular, this course gives students an overview of the IS domain and reference disciplines and the theories in the life cycle of IT in organisations (IT creation, IS development, management of IT function). Subsequently, it covers individual, team, organisational, and societal adoption and outcomes of IT. Last, it discusses theoretical perspectives from a few sample IS areas (e.g., knowledge management, electronic commerce). Specific topics to be covered include: disciplinary overview, theories/frameworks/constructs, IT creation and HCI theories, IS development (SAD, project management, CASE), IT alignment, outsourcing, IT personnel management, organisational and individual adoption of new technologies, communication and group work, organisational IT value and social impact (electronic government), IT change management, service science, and sample areas (e.g., KM and e-commerce).

IS6004 Econometrics for IS Research

Modular Credits: 4
Workload: 2-0-0-3-5
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

Ever since the beginning of research into information systems, economics has been recognised as one of the most important reference disciplines. Economics has made useful contributions to the understanding of information systems research and applications. Some examples include the theory of information, decision analysis, game theory, and econometric methodologies. The objective of this course is to equip graduate students with econometrics research methodologies pertaining to the analysis of IT/IS, and to help students understand emerging IS-economics and econometric issues.

IS6005 Seminars in Information Systems I

Modular Credits: 2
Workload: 2-0-0-0-2
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

This module will consist of a series of research seminars on current and ongoing research in the information systems area. These seminars can be given by graduate students, faculty members and visitors. Through active discussions at the seminars, students will become familiar with current research topics as well as other research issues, such as methodologies and methods. Students will also acquire research presentation and discussion skills. Students must attend and participate to pass the module.

IS6100 Information Systems Research

Modular Credits: 4
Workload: 2-0-0-2-6
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

The course is designed to equip research candidates with the knowledge and expertise to conduct high quality research in Information Systems. Through lectures, seminars, and project work, students will develop both conceptual and methodological skills that are critical to performing excellent IS research. Major topics covered include planning and measurement issues, qualitative approaches such as case study, ethnography, action research, and quantitative approaches such as survey, experiment, and experimental economics. Students are expected to submit a term paper at the end of the course.

IS6101 Topics in Information Systems I

Modular Credits: 4
Workload: 2-0-0-2-6
Prerequisite(s): Variable, depending on the choice of topics or departmental approval.
Preclusion(s): Nil
Cross-listing(s): Nil

Topics will be of an advanced information systems nature and will be selected by the Department.

IS6102 Topics in Information Systems II

Modular Credits: 4
Workload: 2-0-0-2-6
Prerequisite(s): Variable, depending on the choice of topics or departmental approval.
Preclusion(s): Nil
Cross-listing(s): Nil

Topics will be of an advanced information systems nature and will be selected by the Department.

IS6103 Design Science in Information Systems

Modular Credits: 4
Workload: 2-1-0-2-5
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

The information systems field has been energised by a flurry of recent activity that centers on the use of *design research* as an important research paradigm. This has been widely adopted in the IS (Information Systems) community as *Design Science Research* (DSR). In this research oriented class, we will introduce students to the DSR area, including its foundation, techniques and exemplars. Various techniques and methods will be discussed and debated.

IS6201 Seminars in Information Systems II

Modular Credits: 2
Workload: 2-0-0-0-2
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

This module will consist of a series of research seminars on current and ongoing research in the information systems area. These seminars can be given by graduate students, faculty members and visitors. Through active discussions at the seminars, students will become familiar with current research topics as well as other research issues, such as methodologies and methods. Students will also acquire research presentation and discussion skills. Students must attend and participate to pass the module.

IS6202 Seminars in Information Systems III

Modular Credits: 2
Workload: 2-0-0-0-2
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

This module will consist of a series of research seminars on current and ongoing research in the information systems area. These seminars can be given by graduate students, faculty members and visitors. Through active discussions at the seminars, students will become familiar with current research topics as well as other research issues, such as methodologies and methods. Students will also acquire research presentation and discussion skills. Students must attend and participate to pass the module.

4. Freshman Seminar Modules

FMC1201 Freshman Seminar: Is Computer Science Science?

Modular Credits: 4
Workload: 0-3-0-4-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

The objective of this seminar is for freshmen to gain a fundamental understanding of Computer Science and a broader perspective of how it relates to other sciences. The major topics include the similarity and differences between Computer Science, and the traditional sciences (Physics, Biology, Mathematics, etc.), the objective and methodology in Science and the scientific aspects of computation (hardware, software, systems, etc.). This module will be graded as "Completed Satisfactory/Completed Unsatisfactory (CS/CU)".

FMC1202 Freshman Seminar: The Wonderfully Weird World of Software

Modular Credits: 4
Workload: 0-3-0-4-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

In this course, students will examine a number of interesting real-world software phenomena drawn from diverse domains such as viruses, embedded applications, search engines, web applications, mobile applications, operating systems, virtual reality applications and security applications. The mode of delivery is instructor-led discussions flanked with preparatory and follow-up assignments. The discussion offers an "outside-in" look at the respective software, leading to an increased awareness and interest in the related computer science subject areas. Small group teaching with emphasis on inquiry, discovery and exchange of ideas will be used. This module will be graded as "Completed Satisfactory/Completed Unsatisfactory (CS/CU)".

FMC1203 Freshman Seminar: Computational Thinking

Modular Credits: 4
Workload: 0-3-0-4-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

The reach and applicability of computing is vast — essentially all of human endeavours. To deal with the complexity, computer scientists have developed thinking methods that are suited for scaling to large and difficult problems. In this course, students will be exposed to computational thinking methods such as the use of abstraction, compositionality, divide and conquer, caching, reduction, invariants, randomness, and parallelism. Students will do case studies to compare and contrast computational thinking with thinking methods used to organise non-computing domains. Small group teaching with emphasis on discovery and insights as well as communication skills will be used. This module will be graded as "Completed Satisfactory/Completed Unsatisfactory (CS/CU)".

FMC1204 Freshman Seminar: Innovating Radically with IT

Modular Credits: 4

Workload: 0-3-0-4-3

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

This module provides freshmen with insights into how IT has radically transformed industries in the past few decades. A few key industries that are strategic to Singapore (as documented in the iN2015 national IT strategic plan) will be covered. Freshmen will develop insights through readings, field research, and interviews with IT pioneers in these industries. They will share their insights with the class through seminars. Freshmen will then undertake a forward looking project to interpret how emerging forms of IT may be exploited to radically transform these key industries in the future. This module will be graded as "Completed Satisfactory/Completed Unsatisfactory (CS/CU)".

FMC1205 Freshman Seminar: Practical Information Security

Modular Credits: 4

Workload: 0-3-0-4-3

Prerequisite(s): Nil

Preclusion(s): Nil

Cross-listing(s): Nil

In order to appreciate the science of information security, one needs to understand how computer systems can be compromised by insecure design and implementation. In this course, students will be exposed to common security vulnerabilities of modern computing systems, the standard tools that can be deployed to guard against such vulnerabilities, and the best practices to design systems that can minimize not only known security issues, but also future risk arising from currently unknown security attacks. Students will do case studies to investigate how they could potentially compromise some standard computing systems, and propose solutions to mitigate against the risks.

5. Modules for Cross Faculty Students

IT1001 Introduction to Computing

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): Nil

Preclusion(s): CS1010 or CS1010E, CS1101, CS1101C, CS1101S, CZ1102, GEK1511. SoC students and engineering students. Science students requiring this module for their minor should not register it as ULR-Breadth. Arts and social sciences students reading CNM as a subject/concentration and matriculated before AY2001/02 are not allowed to read this module as ULR-Breadth.

Cross-listing(s): Nil

This module aims to provide basic IT understanding for students who have little or no knowledge of computing. It is structured to be the course for students who either plan to take only one course in computing in their entire undergraduate studies or who want to equip themselves to do more specialised computing studies. The module tries to be broad by touching on most aspects of computing. However, there will also be some technical depth in standard introductory computing topics. The lectures will be intensely complemented by Web exploring activities.

IT1002 Introduction to Programming

Modular Credits: 4

Workload: 2-1-0.5-2-3

Prerequisite(s): Nil

Preclusion(s): CS1010 or CS1010E, CS1101 or CS1101C or CS1101S or IF2206; Engineering and SoC students. Science students requiring this module for their minor, should not register it as CFM/ULR-Breadth. Arts and social sciences students reading CNM as a subject/concentration and matriculated before AY2001/02 are not allowed to read this module as ULR-Breadth. Taking IT1002 will preclude one from taking the majority of the CS courses in future, including core and fundamental computing courses like CS1010 or CS1010E or CS1101, CS1102, CS1101C, and CS1102C.

Cross-listing(s): Nil

The aim of this module is to introduce students to programming and abstraction methods as espoused in a modern programming language such as Java. This introductory course on Java introduces object abstraction and object-oriented implementation. The concept of objects and object communication will be reinforced via the rich API library for input/output functionality and graphical user-interface components. Abstraction techniques allow non-trivial programmes to be implemented incrementally and with control on complexity. Laboratory sessions will equip students with hands-on experience in Web pages and Java applets. Projects and assignments will expose students to programming and the use of Java constructs.

IT1003 Information Systems Applications

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): Nil

Preclusion(s): Students from the School of Computing.

Cross-listing(s): Nil

This module leads non-computing students to appreciate the impact of Information System (IS) applications in various industries. It examines the current status, penetration rate, and likely future trends of IS in these industries. It highlights the challenges and potential of implementing IS in these industries. Areas that can be covered include manufacturing, finance (banking and investment), logistics and transportation, tourism and hospitality, food and beverage, entertainment and the arts, healthcare and medicine, legal, communications, education, defence, as well as e-government. Leading IS practitioners from these industries will be invited to share their experience and insights in this module.

IT1004 Introduction to Electronic Commerce

Modular Credits: 4

Workload: 2-1-0-3-4

Prerequisite(s): Nil

Preclusion(s): School of Computing students; CS3266, (CS4260 or IS4260), CS4264, CS4265 or DSC3211 or equivalent

Cross-listing(s): Nil

The Internet is a medium that no business can afford to ignore. The objective of this introductory module is to give non-computing students exposure to electronic commerce, and how it is being applied. Students will learn the basic concepts including electronic commerce infrastructure, security, privacy, threats, social and ethical issues in electronic commerce, electronic commerce payment systems, marketing on the Internet, components of B2C and B2B business models, and various actions in electronic commerce, such as retailing, auctions, portal, E-government.

IT1005 Introduction to Programming with Matlab

Modular Credits: 4

Workload: 3-0-2-2-3

Prerequisite(s): GCE 'A' Level Mathematics or H2 Mathematics, Chemical Engineering students matriculated in and after AY2006/07.

Preclusion(s): CS1010, CS1010E, CS1101S, CG1101, CZ1102, IT1002, IT1006 and its equivalents

Cross-listing(s): Nil

With the widespread use of computers and computational tools in industrial practice and research, it is important for students in the chemical engineering programme to gain a firm understanding and appreciation of the fundamentals of programming, algorithmic problem-solving, coding and debugging. The final goal is to be able to apply these skills to solve realistic chemical engineering problems. MATLAB, a high-level computing language will be employed due to its capability to solve domain-specific computing problems more conveniently than with traditional programming languages. MATLAB also provides the platform to span a wide variety of application areas.

IT1006 MATLAB Programming for Mathematics

Modular Credits: 4

Workload: 3-0-3-2-3

Prerequisite(s): GCE 'A' Level Mathematics or H2 Mathematics

Preclusion(s): IT1005, CS1010, CS1010E, CG1101, CS1101S

Cross-listing(s): Nil

Computers are ubiquitous in most industries, making it important for students in mathematics to gain a firm understanding of the fundamentals of algorithmic problem solving, coding and debugging, and to be able to apply these skills to solving realistic mathematics problems. MATLAB will be employed due to its capability to solve domain-specific computing problems more conveniently than with traditional programming languages, spanning a wide variety of application areas. As this is a light programming course, students taking this course will need to take CS1010 if they intend to take other programming courses offered by the School of Computing.

IT1801 Programming for Business

Modular Credits: 4

Workload: 2-1-1-2-4

Prerequisite(s): Nil

Preclusion(s): Students from the School of Computing

Cross-listing(s): Nil

This module discusses the basic concepts of information technology and the implications of these concepts to users and business management. Students will also use the spreadsheet software as a tool to develop business solutions and use Visual Basic for Applications to enhance their spreadsheet applications.

IT2001 Network Technology and Applications

Modular Credits: 4

Workload: 2-1-0-2-3

Prerequisite(s): (CS1010 or its equivalent) or GEK1511 or IT1001 or IT1002

Preclusion(s): CS2105, EE3204/E, EE4210; SoC, EEE & CPE students are not allowed to take this module. Arts and social sciences

students reading CNM as a subject/ concentration are not allowed to read this module as CFM/ULR-Breadth.

Cross-listing(s): Nil

The objective of the module is to provide technological background in telecommunications, data communication and Internet technology to non-computer science students. It covers the basic concepts in communication and networking, and looks at Internet and telecommunications in detail. It also deals with some common applications in all these areas and looks at the possible convergence of various communication technologies. The impact on social and business areas as a result of the widespread use of the fast-changing communication technologies is also addressed.

IT2002 Database Technology and Management

Modular Credits: 4

Workload: 2-1-0.5-2-3

Prerequisite(s): (CS1010 or its equivalent) or IF2206 or IT1002

Preclusion(s): CS2102 or CS2102S. SoC students and Arts and social sciences students reading CNM as a subject/concentration are not allowed to read this module as CFM/ULR-Breadth.

Cross-listing(s): Nil

The aim of this module is to provide students with practical knowledge and understanding of basic issues and techniques in data management, with sufficient theory to understand the reasons for these techniques. Topics include conceptual (entity relationship model) and logical design (relational model) of database models, relational database management (data definition, data manipulation, SQL, visual interactive query interfaces), and their use in application development (in particular, data extraction from DBMS to spreadsheets application and data extraction to Web applications). Projects in developing a database within an application form an essential component of this module.