

3 Department of Computer Science

3.1 Bachelor of Computing in Computer Science

3.1.1 Overview

The 4-year **Computer Science programme** aims to develop graduates with a strong technical knowledge of computer science and technology. The programme emphasizes the fundamentals of the four pillars of computer science, viz. *programming languages, theory/algorithms, computer systems, and human-computer interaction*.

The programme is structured around the U.S. Association of Computing Machinery and the IEEE Computer Society's *Computing Curriculum 2001* recommendations.

Possible jobs for Computer Science graduates include R&D engineer/specialist, system consultant, technical support specialist and software specialist. Possible employers include software developers, commercial research organizations, and tertiary institutions.

3.1.2 Degree Requirements

The Computer Science programme requirement is at least 135 modular credits. Modules are divided into:

- (i) **COMMON ESSENTIALS**
 - CS1101/CS1101S Programming Methodology
 - CS1102 Data Structures and Algorithms
 - CS1104 Computer Organisation
 - CS1105 Computing and Society
 - CS2102S Introduction to Database Systems
 - CS2103 Software Engineering
 - CS2105 Computer Networks I

- (ii) **PROGRAMME ESSENTIALS**
Computer Science Related
 - CS1231S Discrete Mathematics (Accelerated)⁵
 - CS2106 Operating Systems
 - CS3212 Programming Languages
 - CS3214S Software Engineering Project
 - CS3230 Design and Analysis of Algorithms
 - CS4101 Honours Project
 - CS4102 Technical & Management Training
 - Minimum of 2 modules from the following list of 6 modules:

⁵ Students with weaker Mathematics background may wish to take both CS1231 and CS1232 in place of CS1231S.

- CS3211 Parallel and Concurrent Programming
- CS3220 Computer Architectures
- CS3231 Automata Theory and Formal Languages
- CS3234 Logic & Formal Systems
- CS3236 Scientific Computing
- CS3243 Foundations of Artificial Intelligence

Science Related

- MA1102 Calculus
- A Physics Module
- A Biology Module

(iii) *PROGRAMME ELECTIVES*

Choose four level-4 modules from elective areas A1 to A4.

(iv) *BREADTH REQUIREMENT*

- University Level Requirements (ULR)⁶
- CS2301 Business and Technical Communication
- Human Resource Management

(v) *FREE ELECTIVES*

Pass an appropriate number of modules to make up **135 modular credits**.

⁶ Please see page 10 on University Level Requirements

Table 2: Curriculum Structures for B.Comp (Computer Science) for the Academic Year 2001/2002

Modules	B.Comp. in CS (AY2001/2002) Modular Credits
Common Essentials	
CS1101/S Programming Methodology	5
CS1102 Data Structures and Algorithms	5
CS1104 Computer Organization	4
CS1105 Computing and Society	3
CS2102S Introduction to Database Systems	4
CS2103 Software Engineering	4
CS2105 Computer Networks I	4
<i>Subtotal MC</i>	29
Programme Essentials	
(i) Computer Science Related	
CS3214S Software Engineering Project	8
CS1231S Discrete Mathematics (Accelerated)	4
CS2106 Operating Systems	4
CS3212 Programming Languages	3
CS3230 Design and Analysis of Algorithms	3
Modules from CS Programming Essential list	6 (2 modules)
CS4101 Honours Project	12
CS4102 Technical & Management Training	X
(ii) Science Related	
MA1102 Calculus	5
A Physics Module	4
A Biology Module	4
<i>Subtotal MC</i>	53
Programme Electives	
Level-4000 modules	Pass 4 modules
<i>Subtotal MC</i>	12
Breadth Requirement	
ULR	28
Human Resource Management	3
CS2301 Business and Technical Communication	3
<i>Subtotal MC</i>	34
Free Electives (from any faculty)	7
Total	135 MC

3.2 Bachelor of Computing in Computer Engineering

3.2.1 Introduction

The **Bachelor of Computing in Computer Engineering** is a four-year programme offered by the School of Computing from July 2000. Prior to July 2000, the Bachelor of Engineering (Computer Engineering) programme was jointly administered and organized by the School of Computing and the Electrical & Computer Engineering (ECE) Department in the Faculty of Engineering. It is now offered solely by the ECE Department. This note describes the B.Comp. (CE) programme. In a nutshell, both the B.Eng. (CE) and B.Comp. (CE) programmes cover hardware as well as software with the former having a more of a hardware focus and the latter having a more of a software focus.

The recent decade has seen rapid advances moving computing from the PC into everyday appliances, and there is the concomitant advent of ubiquitous networking. A new breed of computer scientists with a deep appreciation of hardware issues is needed. This programme's goal is to provide an integrated view of software-hardware design. This is very important for the area of embedded computing systems which require a solid understanding of the physical hardware issues with the ability of computer science abstraction in order to effectively tackle their complexity. Consequently, this programme will train computer scientists with a solid foundation in the fundamentals of computing as well as a keen appreciation of hardware to work creatively with the next generation of embedded systems -- mobile computing devices, internet appliances, wearable computing and digital entertainment systems.

This programme should be distinguished from the B.Eng. (Computer Engineering) degree. The latter is closely related to the electrical engineering degree and the curriculum is designed in accordance with the requirements of the Faculty of Engineering and the Professional Engineers Board. The B.Comp. in Computer Engineering degree meets the standard requirements of the 4-year Bachelor of Computing in Computer Science; both of which are structured around the US Association of Computing Machinery (ACM) and the IEEE Computer Society's draft "Computing Curriculum 2001" recommendations. A student pursuing the B.Comp. in CE degree has tremendous flexibility and opportunity to combine computer science and electrical engineering courses with elective courses from other Faculties such as Business, Arts and Social Sciences, or Science or take advanced courses in computer science. Furthermore, the School of Computing plans to offer a set of new elective modules on advance software techniques for embedded systems. The programme caters for those with different professional and educational aspirations as well as provides a superb grounding for alternative future developments. To summarize, the graduate will be a computer scientist with good electronics and hardware knowledge with deep insights into the emerging area of embedded systems. This special set of skills coupled with the freedom of the electives allows the graduate to position himself/herself in a large number of upcoming and exciting fields of work including:

- Network: wireless application, network management, design and deployment of networks, Internet appliances, WWW development etc.

- New media: multimedia, design and development of edutainment, digital audio & speech, digital video, etc.
- Mission critical systems: robotic control, fault tolerant systems, real-time systems, etc.
- Embedded software: software control of systems ranging from photocopiers to chemical processing plants, etc.
- Design automation: CAD/CAM tools, hardware-software co-design, next generation firmware, etc.
- Ubiquitous systems: smart consumer electronics, defense applications, low-power portable devices, wearable computing, etc.

The details of the B.Comp. (CE) programme are available at the web-site:

<http://www.comp.nus.edu.sg/~cmcurric/index.html>

3.2.2 Degree Requirements

The Computer Engineering programme requirement is at least 135 modular credits. Modules are divided into:

- (i) *COMMON ESSENTIALS*
 - CS1101/CS1101S Programming Methodology
 - CS1102 Data Structures and Algorithms
 - CS1104 Computer Organisation
 - CS1105 Computing and Society
 - CS2102S Introduction to Database Systems
 - CS2103 Software Engineering
 - CS2105 Computer Networks I

- (ii) *PROGRAMME ESSENTIALS*
 - Computer Science Related
 - CS1231S Discrete Mathematics (Accelerated)⁷
 - CS2106 Operating Systems
 - CS2271 Introduction to Embedded Systems
 - CS3211 Parallel and Concurrent Programming
 - CS3212 Programming Languages
 - CS3214S Software Engineering Project
 - CS3220 Computer Architecture
 - CS3230 Design and Analysis of Algorithms
 - CS4101 Honours Project
 - CS4102 Technical & Management Training

 - Mathematics Related
 - Mathematics Module 1⁸

⁷ Students with weaker Mathematics background may wish to take both CS1231 and CS1232 in place of CS1231S.

⁸ EG1401 Mathematics A

- Mathematics Module 2⁹

Computer Engineering Related

- EE2005 Electronics
- EE3101 DSP Fundamentals
- EG1103 Electrical and Computer Engineering

(iii) *PROGRAMME ELECTIVES*

Choose four level-4 modules from elective areas A1 to A4, A7 and E2. Elective modules listed in E2 will be available on the web.

(iv) *BREADTH REQUIREMENT*

- University Level Requirements (ULR)¹⁰
- CS2301 Business and Technical Communication
- Human Resource Management

(v) *FREE ELECTIVES*

Pass an appropriate number of modules to make up **135 modular credits**.

⁹ EG1402 Mathematics B

¹⁰ Please see page 10 on University Level Requirements.

Table 2. Curriculum Structures for the Bachelor of Computing in Computer Engineering Programmes for the Academic Year 2001/2002

Modules	B.Comp. (CE) AY2001/2002 Modular Credits
Common Essentials	
CS1101/S Programming Methodology	5
CS1102 Data Structures and Algorithms	5
CS1104 Computer Organization	4
CS1105 Computing and Society	3
CS2102S Introduction to Database Systems	4
CS2103 Software Engineering	4
CS2105 Computer Networks I	4
<i>Subtotal MC</i>	29
Programme Essentials	
(i) Computer Science Related	
CS3214S Software Engineering Project	8
CS1231S Discrete Mathematics (Accelerated)	4
CS2271 Introduction to Embedded Systems	3
CS2106 Operating Systems	4
CS3212 Programming Languages	3
CS3220 Computer Architecture	3
CS3230 Design and Analysis of Algorithms	3
CS3211 Parallel and Concurrent Programming	3
CS4101 Honours Project	12
CS4102 Technical & Management Training	X
(ii) Mathematics Related	
Mathematics Module 1 ¹¹	3
Mathematics Module 2 ¹²	3
(iii) Computer Engineering Related	
EE2005 Electronics	3
EE3101 DSP Fundamentals	3
EG1103 Electrical and Computer Engineering	3
<i>Subtotal MC</i>	58
Programme Electives	
Electives	Pass 4 modules
<i>Subtotal MC</i>	12
Breadth Requirement	
ULR	28
Human Resource Management	3
CS2301 Business and Technical Communication	3
<i>Subtotal MC</i>	34
Free Electives (from any faculty)	2
Total	135 MC

¹¹ EG1401 Mathematics A

¹² EG1402 Mathematics B

3.3 Bachelor of Computing

3.3.1 Overview

The **3-year Bachelor of Computing programme** is designed to provide a sound scientific education, targeted at the needs of local and regional IT users and vendors. The programme combines *theoretical training* with *practical technology experience*. Students will develop professional competence in programming, abstraction, and conceptual skills of computing.

Graduates will meet national IT manpower needs in major job segments such as programmer analyst, systems analyst, systems programmer, system integrators and end user support analyst. They will be able to contribute immediately to the development needs of the local and regional economies.

Students in this programme are required to choose a focus of study. In order to meet diverging demand in IT practice, the 3-year Bachelor of Computing Programme consists of two foci of studies:

- 1 The **Technology focus** aims to equip students with strong technology know-how so that they can stride forward alongside the advancement of computing technology.
- 2 The **Business focus** aims to equip students with sound business knowledge in relation to information technology, including the operation of e-Commerce.

3.3.2 Degree Requirements

For the 3-year Bachelor of Computing programme, a candidate must read the following modules:

- (i) **COMMON ESSENTIALS**
 - CS1101/CS1101S Programming Methodology
 - CS1102 Data Structures and Algorithms
 - CS1104 Computer Organisation
 - CS1105 Computing and Society
 - CS2102/S Introduction to Database Systems
 - CS2103 Software Engineering
 - CS2105 Computer Networks I
- (ii) **PROGRAMME ESSENTIALS**
 - CS3214/S Software Engineering Project
 - Choose either one of the following groups of modules:

1. Technology focus

- CS1231 Discrete Mathematics I ¹³
- CS1232 Discrete Mathematics II
- CS2104 Programming Language Concepts
- CS2106 Operating Systems
- A Biology Module

2. Business focus

- EC1310 Principles of Economics¹⁴
- CS2250 IS Theory and Practice
- CS3265 Economics of e-business
- CS3266 e-Commerce Technologies

(iii) *PROGRAMME ELECTIVES*

Satisfy one of the following requirements, depending on students' focus:

1. Technology focus

Choose five modules from elective areas A1 to A8, with at least two modules chosen from the following list: modules in Area A8, CS3235 (Computer Security), CS3240 (Human Computer Interaction), CS3266 (e-Commerce Technologies), and CS3103 (Computer Networks II).

2. Business focus

Choose five modules from elective areas A1 to A8, with at least two modules chosen from the following list: modules in Area A6, CS3253 (Management of Information Systems), and CS3251 (Technology Strategy and Management).

(iv) *BREADTH REQUIREMENT*

- University Level Requirements¹⁵
- CS2301 Business and Technical Communication
- Human Resource Management

(vi) *FREE ELECTIVES*

Pass an appropriate number of modules to make up **105 modular credits**.

¹³ Students with strong Mathematics background may wish to take CS1231S in place of CS1231 and CS1232. Note that the modular credit for CS1231S is 4 whereas the combined MC for CS1231 and CS1232 is 6.

¹⁴ Candidates who obtained a pass in Economics in the GCE Singapore-Cambridge A-level examinations are deemed to meet this requirement without modular credits.

¹⁵ Please refer to page 10 on University Level Requirements.

Table 2. Curriculum Structures for the 3-year Bachelor of Computing programmes with Technology and Business Focus

Modules	B.Comp. with Technology focus	B.Comp. with Business focus
Common Essentials	Modular Credits	Modular Credits
CS1101/S Programming Methodology	5	5
CS1102 Data Structures and Algorithms	5	5
CS1104 Computer Organization	4	4
CS1105 Computing and Society	3	3
CS2102 Introduction to Database Systems	3	3
CS2103 Software Engineering	4	4
CS2105 Computer Networks I	4	4
<i>Subtotal MC</i>	28	28
Programme Essentials		
(i) Computer Science Related		
CS3214/S Software Engineering Project	8	8
CS1231 Discrete Mathematics I ¹⁶	3	-
CS1232 Discrete Mathematics II	3	-
CS2104 Programming Language Concepts	3	-
CS2106 Operating Systems	4	-
(ii) Information System Related		
EC1310 Principles of Economics	-	4
CS2250 IS Theory and Practice	-	3
CS3265 Economics of e-business	-	3
CS3266 e-Commerce Technologies	-	5
(iii) Science Related		
A biology module	4	
<i>Subtotal MC</i>	25	23
Programme Electives		
Electives	Pass 5 modules	Pass 5 modules
<i>Subtotal MC</i>	15	15
Breadth Requirement		
ULR	20	20
CS2301 Business & Tech Communications	3	3
Human Resource Management	3	3
Free electives (from any faculty)	11	13
Total	105 MC	105 MC

¹⁶ Students with good mathematics background may wish to take the accelerated version of Discrete Mathematics (CS1231S). This accelerated module replaces both CS1231 and CS1232, but with a modular credit of 4MC.

3.4 Bachelor of Computing (Communications & Media)

3.4.1 Introduction

Since the mid-1990s, we have witnessed the phenomenal growth of the Internet. The Internet has had a tremendous impact on key aspects of our daily life, including commerce, information dissemination, communications, education, and the empowerment of individuals with new forms of expression. The increasing adoption of digital media—in print, broadcast, and the world-wide-web (WWW)—is profoundly changing the nature of human expression, learning, and communication. Art can now be created digitally. Learning can be accessed electronically.

The combination of the Internet, media technology, and mass communication techniques also ushers in an era of mass customized communication. The Internet facilitates mass communication by allowing the same digital information to reach any part of the world and to be easily accessed by a large number of end-users. The web can also employ sophisticated computing techniques to flexibly customize information to the needs of individual users. Thus, end-users need no longer remain as end-consumers of information. Multimedia literacy together with the skills of design and content creation empower individuals with fresh avenues of individual as well as artistic expression. At the same time, organizations continue to utilize the WWW to disseminate corporate, governmental, or institutional information.

Unlike traditional broadcast media, the Internet offers conventional *push* technology as well as interactive *pull* technology for information dissemination, thus allowing a spectrum of communication possibilities ranging from pure broadcast to mass customized to individually personalized communication. Effective content design and use of digital media allows individuals, groups, and organizations to leverage the technology to maximum effect.

3.4.2 Goals

The goal of this program is to address the fast emerging discipline of digital media and its effective management and communications. It is a multi-disciplinary program that integrates content design and mass communication techniques with the internet, www, and digital media technology. It will have long-term significant impact in our life and offer challenges in both academic research and curriculum design.

The program aims to produce computing technologists with a good knowledge of artistic design and human communications. At a minimum, students will acquire skills to contribute in the:

- Creative generation and effective communication of digital information for mass yet customized communications; and
- Development and application of enabling computing technologies for mass and personalized communications.

The program will expose students to both the computing and design cultures in early stages of their study. It is designed as a joint program between the School of

Computing, the Faculty of Arts and Social Sciences, with participation from the University Scholar's Program. The program aims to build on the strength of NUS in pursuing multi-disciplinary academic research and teaching.

3.4.3 Targeted Industry

The program targets industries in the knowledge-based economy, including entertainment industry, information and news service organizations, publishers, government agencies, public relations services in organizations, advertising and media relations, consultancy, educational institutions and R&D organizations. New careers in the knowledge-based economy increasingly require expertise and in-depth understanding of multiple disciplines. The graduates from this programme will therefore be well placed to: (a) lead R&D and technical development efforts in media and information related projects; (b) provide technical expertise and support in large content design and creation team; (c) engage in marketing and technical support of media related products and services; and (d) last but not least, assume the role of knowledge, media or information specialists, typically require in new knowledge-oriented organizations.

3.4.4 Overview

This program aims to train students in the technological underpinnings of Internet technologies as well as the required skills of media design and content creation tempered with a proper understanding of the social sciences. Therefore, the program has been designed to achieve an integrated foundation in all these aspects. Since this program involves aspects of computing and the arts and social sciences, it can be viewed from two perspectives:

TECHNOLOGY PERSPECTIVE:

- Foundations of it: this refers to the computing basics required to understand, architect, and extend the internet-based systems.
- Information encoding, information customization, content-repurposing: the encoding, such as the xml, is required for information to be mass communicated on the internet and www. The customization refers to the personalization of information to individuals/groups which the technology allows, and repurposing refers to the customization of information to the heterogeneous networks (wired and wireless) as well as the plethora of end-devices (static and mobile with varying display plus communication capabilities).
- Text, multimedia information analysis and processing: these refer to the technological basis of the various digital media (text, image, graphics, audio and video) and the various types of processing, such as data-rate transformation, summarization etc.
- Entertainment technology: This refers to technologies required to develop interactive games and virtual reality systems.
- Internet architecture: this refers to the technical aspects of the internet including networking, client-server architecture, and issues related to scalability, reliability and availability.

CONTENT AND USER PERSPECTIVE:

- Foundation (sociology): This refers to the required social sciences foundation to contextualize the use of media for communication by individuals and groups in human society.
- Human–Computer Interaction: This refers to the human-centered design of intuitive and flexible interfaces for people to communicate via the end-devices of the Internet fringes.
- Writing, and Media Design for Mass Communication: This refers to the required arts background, which enables the creative use of digital media for the purpose of expression and communication. The media considered include hypertext, audio, image/graphics, and video.
- Mass Communication on Internet: This refers to the theoretical and empirical principles of mass communications on the WWW.

3.4.5 Degree Requirements

For the degree of Bachelor of Computing(Communications and Media) programme, a candidate must read the following modules:

(i) *IT ESSENTIALS (51 MC)*

Basic Foundation and Common Cores of SoC

CS1101/CS1101S Programming Methodology (5 MC)

CS1102 Data Structures and Algorithms (5 MC)

CS1104 Computer Organization (4 MC)

CS2102 Database Systems (3 MC)

CS2103 Software Engineering (4 MC)

CS2105 Computer Networks I (4 MC)

CS1231S Discrete Mathematics (4 MC)

CS4101 Honours-Level Media Project (12 MC)

Media Technologies

CS3241 Introduction to Computer Graphics (3 MC)

CS3242S Hypermedia Technologies (project-emphasis) – (4 MC)

Internet Technologies

CS3224 Architecture of Internet (3 MC)

(ii) *Content Creation and Mass Communications ESSENTIALS (26 MC)*

HCI

CS3240 Human Computer Interaction (3 MC)

Media Design and Creation

IF2208 Principles of Visual Communications (4 MC), or

CS1240 New Media Art (4 MC)

IF3209 Hypertext Theory: Writing in the Electronic Era (4 MC)

Design of Interactive Media (3 MC)

Effective Communications

IF1101/E Information Revolution & Society (4MC)

IF2101 Media Communications (4 MC)

Contents (4 MC)

Choose one problem-based content-oriented module from below:

SC3213 Ethnographic Film-Making

IF3208 Design Contents for new Media

SW3203 Communications and Public Education

(iii) **BREADTH REQUIREMENTS**

University Level Requirements(ULR) (28 MC)

HRM (3 MC)

Physics or Biology (4MC)

(v) **CM and FREE ELECTIVES to make up at least 135 modular credits.**

Choose any modules with at least:

1 module from Group A (Media & Internet Technology).

1 module from Group B (Content Creation and Mass Communications).

4 modules at level 4000 or above (excluding CS4101, CS4102)

4 Free Electives

The modules available in the CM elective groups are:

A. **MEDIA & INTERNET TECHNOLOGY**

- Foundation of AI
- Multimedia Information Systems
- Text Processing on the Web
- Natural Language Processing
- Speech and Audio Processing
- Image Synthesis and Computer Animation
- Virtual Reality and 3D Interaction
- Games Development
- Multimedia and Internet-based learning environments
- Design of advanced user interfaces

B. **CONTENT CREATION & MASS COMMUNICATIONS**

- Culture & Communications
- Economics of Info & Comm
- Themes In Internet Studies
- Ethnographic Film-making
- Design Contents for new Media
- Communications and Public Education
- Chinese Drama (in Chinese)
- Media, Globalization & IT
- Culture Industries
- Transnational Info Producers
- Ethics in the Information Age
- Digital Media Project Management

Detail module description will be made available over the web.

3.4.6 University Scholar's Programme

Bachelor of Computing (Communications and Media) students in the University Scholars Programme (USP) will adopt the following variations of the above programme:

They will elect the 8 Core modules in place of University requirements (32 MC).

They will do the following 4 required modules at USP level:

- Data Structures and Algorithms (TDCS1102)
- Software Engineering (TDCS2103)
- Hypermedia Technologies (in place of UROP module CS3208)
- Design of Interactive Media (in place of UROP module CS3209)

The last two modules have strong project-emphasis.