School of Computing

Faculty's Commitment

Brief Introduction

Established in 1998, NUS School of Computing (SoC) is Asia's leading computing school, with an excellent record of nurturing research-driven and enterprising graduates who thrive in various sectors of the economy. From biomedicine to finance and various high-tech industries, it counts among its alumni chief executives and technology architects of multinationals, government agencies, and flourishing start-ups.

SoC comprises two academic departments and is home to 2,000 students, with a quarter of them pursuing graduate studies. Through a well-rounded curriculum taught by a distinguished faculty, its students are empowered to be innovation drivers who are capable of making the world a better place.

The School inculcates in its students computational thinking and life-long learning skills, equipping them with the right balance of scholarly excellence, professionalism, and soft skills. SoC's graduates are highly sought after. Leading computing companies such as Facebook, Google, and Microsoft send recruiters to them to recruit for their engineering centers worldwide. SoC's graduates play a pivotal role in Singapore's effort to improve productivity and streamline government, and to become a leading center for various industries such as finance, logistics, media, and technology.

The School offers undergraduate degree programmes that are undergirded by strong grounding in the fundamentals of computer science, covering four main areas of specialisation: computational biology, business, computer engineering, information security and digital media. We also offer graduate degree programmes by coursework or research, with greater intensity in focus within these areas of specialisations.

The curricula are designed according to the recommendations of the Association for Computing Machinery (ACM), the Association for Information Systems (AIS), and the Computer Society of the Institute of Electrical and Electronic Engineers (IEEE), which are the foremost authorities in the field of computing. Consequently, the knowledge units that are to be imparted within the curricula are recognised internationally, the practices instilled are sensitive to industrial development, and the pedagogy espoused adheres to tertiary IT education standards worldwide.

The research initiatives at SoC are supported by a number of research laboratories and centres within the School. Fitted with equipment that is funded mainly by research grants, the laboratories and centres provide a common space for people with similar interests to exchange ideas and work together informally.

The School is governed by the Executive Committee, and operates in consultation with an Industry Advisory Board.

Educational Philosophy

The programmes offered by the Department of Computer Science are founded on a wide variety of disciplines, with the goal of producing computer scientists who can integrate computing-related theories and practices, recognise the importance of abstraction, and appreciate the value of good engineering design.

These programmes seek to prepare students for life-long learning that will enable them to move beyond today's technology to meet the challenges of the future. Furthermore, they include professional practices as an integral component of the undergraduate curriculum. These practices encompass a wide range of activities including management, ethics and values, written and oral communication, and team work.

The programmes offered by the Department of Information Systems are multidisciplinary in nature. In addition to providing students with a strong foundation in computer science, these programmes also give students the benefits of learning from other disciplines, such as business studies and economics. The modules required by these programmes reflect their objectives, which are to train graduates who are able to develop and manage business information systems and who understand how Internet technology can be deployed in business and organisations. Consequently, students are given the wide option of taking less technical, more business-oriented modules offered by the Department as well as the School of Business.

The School has also gained recognition from ABET Inc., the world respected US-based accreditation agency, for its Computer Science programmes. The agency certified that the programmes are "substantially equivalent" to accredited programmes in the United States, which is the standard status that the agency offers to universities outside the United States.

Please refer to: http://www.comp.nus.edu.sg for up-to-date information on the School.

For more detailed information, please visit the School's website at: http://www.comp.nus.edu.sg

Title & Name	Designation/Responsibility	Telephone (6516-XXXX)	Email (XXXX@nus.edu.sg)
Prof ROSENBLUM, David S.	Dean	4782	comdean@nus.edu.sg
Prof JAIN, Sanjay	Vice-Dean (Academic Affairs)	7842	sanjay@comp.nus.edu.sg
Assoc Prof Gary TAN	Associate Dean & Vice-Dean (Student Life)	6276	gtan@comp.nus.edu.sg
Assoc Prof BROWN, Michael Scott	Vice-Dean (External Relations)	7097	brown@comp.nus.edu.sg
Assoc Prof ROYCHOUDHURY, Abhik	Assistant Dean (Graduate Studies)	8939	abhik@comp.nus.edu.sg
Prof NG Hwee Tou	Vice-Dean (Research)	8951	nght@comp.nus.edu.sg
Assoc Prof LEE Wee Sun	Vice-Dean (Undergraduate Studies)	4526	leews@comp.nus.edu.sg
Assoc Prof CHAN Mun Choon	Assistant Dean (Graduate Studies)	7372	chanmc@comp.nus.edu.sg
Dr GOH Khim Yong	Assistant Dean (External Relations)	2832	gohky@comp.nus.edu.sg
Assoc Prof KAN Min-Yen	Assistant Dean (Undergraduate Studies)	1885	kanmy@comp.nus.edu.sg
Assoc Prof KANKANHALLI, Atreyi	Assistant Dean (Research Programmes)	4865	atreyi@comp.nus.edu.sg
Assoc Prof LIANG Zhenkai	Assistant Dean (Graduate Studies)	1226	liangzk@comp.nus.edu.sg
Mr Aaron TAN	Assistant Dean (Undergraduate Studies)	2906	tantc@comp.nus.edu.sg
Assoc Prof Irene WOON	Assistant Dean (Undergraduate Studies)	6296	iwoon@comp.nus.edu.sg
Prof TAN Kian Lee	Head Department of Computer Science	2862	dcshead@nus.edu.sg
Prof Wynne HSU	Deputy Head, Department of Computer Science	7944	whsu@comp.nus.edu.sg
Assoc Prof TEO Hock Hai	Head, Department of Information Systems	4368	dishead@nus.edu.sg
Assoc Prof HAHN, Jungpil	Deputy Head, Department of Information Systems	7345	jungpil@comp.nus.edu.sg
Mr Aaron TAN	Academic Advisory Coordinator	2906	tantc@comp.nus.edu.sg
Assoc Prof ANDERSON,	Undergraduate	4262	

Title & Name	Designation/Responsibility	Telephone (6516-XXXX)	Email (XXXX@nus.edu.sg)
Hugh	Advisor (for students matriculated in AY2012-13 and AY20154-165)		hugh@comp.nus.edu.sg
Dr Alan CHENG	Undergraduate Advisor (for students matriculated in AY2011-2012, AY2013-14 and AY2015-16)	8732	hcheng@comp.nus.edu.sg
Mr LEK Hsiang Hui	Undergraduate Advisor (for students matriculated in AY2015-16)	6601 1049	lekhsian@comp.nus.edu.sg
Dr RAMCHAND, Anand Mohan	Undergraduate Advisor (for students matriculated in AY2011-2012 and AY2014-15)	2990	anand@comp.nus.edu.sg
Dr SOO Yuen Jien	Undergraduate Advisor (for students matriculated in AY2014-15)	1345	sooyj@comp.nus.edu.sg
Assoc Prof TAN Sun Teck	Undergraduate Advisor (for students matriculated in AY2011-2012, AY2013-14)	2778	tanst@comp.nus.edu.sg
Dr TAN Gek Woo	Undergraduate Advisor (for students matriculated in AY2012/13)	4888	tangw@comp.nus.edu.sg
Dr WADHWA, Bimlesh	Undergraduate Advisor (for students matriculated AY2010/11, AY2012/13 and AY2014-15)	2973	bimlesh@comp.nus.edu.sg
Assoc Prof Irene WOON	Undergraduate Advisor (for students matriculated in AY2010/11 and AY2013-14)	6296	iwoon@comp.nus.edu.sg
Mr YANG Zhenbin	Undergraduate Advisor (for students matriculated in AY2014-15)	2807	zhenbin@comp.nus.edu.sg
Ms TOH Mui Kiat	Associate Director (Undergraduate Studies)	6735	comtohmk@nus.edu.sg
Ms Agnes ANG	Senior Manager (Graduate Studies)	5242	comanga@nus.edu.sg
Ms Jane LIM	Senior Manager (External Relations)	4371	comlimls@nus.edu.sg
Ms Pamela LIM	Manager (Undergraduate Studies)	4370	comlmf@nus.edu.sg
Mr LOW Mun Bak	Manager (Undergraduate Studies)	5129	comlowmb@nus.edu.sg

Title & Name	Designation/Responsibility	Telephone (6516-XXXX)	Email (XXXX@nus.edu.sg)
Ms Adele Chiew	Senior Executive (Student Life)	2728	comcmla@nus.edu.sg

jQuery(".views-field-title").addClass("hideifnotable");

Title & Name	Designation/Responsibility	Telephone (6516-XXXX)	Email (XXXX@nus.edu.sg)
Ms Adele Chiew	Senior Executive (Student Life)	2728	comcmla@nus.edu.sg

jQuery(".views-field-title").addClass("hideifnotable");

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3 Undergraduate Education

The School of Computing aims to provide a sound and forward-looking education to equip graduates for careers in IT and related fields. To this end, our courses integrate problem-solving skills with a foundation in IT and business. Graduates will be able to integrate new technology and develop themselves into future IT leaders, and to proceed to further studies.

The School offers direct entry to four-year undergraduate degree programmes, designed to meet the needs of distinct segments of the IT job market, and to better serve students with different interests, background, abilities and career orientation. Four-year programmes are designed to educate tomorrow's technical leaders who will pioneer the development of novel technology. The programmes emphasise in-depth mastery of the scientific, engineering and organisational foundations that underlay the continuing progress in information and communications technologies and their applications. **The maximum candidature period for a four-year programme is five years.**

3.1 Degrees Offered

The School of Computing offers five full-time Bachelor of Computing programmes, leading to:

- Bachelor of Computing in Computational Biology;
- Bachelor of Computing in Computer Science;
- Bachelor of Computing in Information Security;
- Bachelor of Computing in Information Systems; and
- Bachelor of Science in Business Analytics

Its Department of Computer Science jointly offers the following full-time Bachelor of Engineering programme with the Department of Electrical and Computer Engineering, Faculty of Engineering:

- Bachelor of Engineering in Computer Engineering

The School also offers a wide array of minors and special programmes to full-time undergraduate students to provide more breadth and depth in their studies.

Please refer to our School's web page at: http://www.comp.nus.edu.sg/undergraduates for the latest details on the degree programmes.

3.2 Degree Requirements

3.2.1　　Programme Structure

The overall degree requirement is based on Modular Credits, with at least 160 Modular Credits (MCs) for the four-year programmes. To graduate, a student must obtain a Cumulative Average Point (CAP) of not less than 2.00.

Each programme consists of modules divided into three main categories:

1. **Programme Requirements**
2. **University Level Requirements (ULR)**
3. **Unrestricted Electives**

A module can only be counted towards one category. No double counting is allowed.

The **University Level Requirements (ULR)** aim to connect disciplinary knowledge and perspectives with the skills needed for lifelong learning beyond the university. The ULR is worth 20 modular credits.

The principles are to:

- Equip students with general knowledge that extends beyond disciplinary facts, theories and methods, to foster an understanding of how disciplines contribute to an understanding of human society and culture.
- Expose students to a diverse range of knowledge and ideas, disciplinary and cross disciplinary perspectives, approaches, and methods that characterize the range of human understanding and that sparks intellectual curiosity, and promotes tolerance of difference and respect for diversity.
- Emphasize the importance of developing clarity of thought and argumentation, critical thinking and reasoning skills, and an appreciation for debates and balanced viewpoints.
- Integrate learning by facilitating an understanding of complex issues and challenges, and their applications to human society and culture.

Students will be required to read one General Education Module (GEM) from each of the five pillars (total: 20 Modular Credits/MCs) to satisfy the University Level Requirement for General Education. The five pillars are: Asking Questions, Human Cultures, Quantitative Reasoning, Singapore Studies, and Thinking and Expression. Students must complete an approved GE module within the Thinking and Expression pillar that satisfies the communication requirement for SoC degrees. The current approved module list includes GET1006 Critical Thinking in the Information Age and GET1021 Critical Thinking and Writing. Please refer to the GEM website at http://www.nus.edu.sg/registrar/gem for the details.

Unrestricted Electives enable students to pursue their academic interests and aspirations. Students may also use Unrestricted Electives to satisfy partially or wholly the requirements of other programmes. As long as the appropriate prerequisites are met, students can satisfy the Unrestricted Electives requirement by taking modules from any of the Departments/Faculties at any level.

The limit on the number of Level-1000 modules to be counted towards fulfilment of graduation requirements is 60 MCs for 160-MC programmes for students admitted from AY2007-8 onwards.

For students admitted from AY2007/8 onwards, the maximum candidature for:

1. a Bachelor with Honours degree with a minimum of 160 MCs is five years; and
2. a typical double degree programme (which may involve between 180 and 200 MCs) is six years.

Programme Structure for Bachelor of Computing Programmes

Industrial Experience Requirement

Degrees offered by both the Department of Computer Science and Department of Information Systems will require 12 MCs of industrial experience content. Students with Polytechnic Diplomas who have completed internship during polytechnic study are exempted 6 MCs of Industry Experience Requirement and only need to complete 3-month internships through CP3202 Internship II (6 MCs) if they **are enrolled for programmes in the Department of Computer Science**. The 6-MC internship exemption for polytechnic graduates is awarded in recognition of their internship experience done during the polytechnic study. These exemptions will be diploma specific as not all diplomas include internships and will be done as part of the Advance Placement Credits granted for the programme requirement.

CP4101 B.Comp. Dissertation

Students in the Department of Computer Science who aim for Honours (Highest Distinction) must pass the CP4101 B.Comp. Dissertation. Students with CAP of 4.0 or higher at the end of their fifth semester of undergraduate study may opt to replace the Industry Experience Requirement by B.Comp Dissertation (12 MCs). Students doing double degrees, concurrent degrees and CS special programme (except Turing Programme) and other students with CAP of 4.0 or higher, may opt to replace Industry Experience Requirement by B.Comp. Dissertation.

Programme selection or course transfer

Transfer of programmes between the two departments: Computer Science and Information Systems follows the course transfer procedure administered by the NUS Office of Admissions at: http://www.nus.edu.sg/oam. Students may request to be transferred into the Bachelor of Engineering (Computer Engineering) programme at the end of the second semester. Success of transfer will depend on the quota available in the targeted programme and the academic standing of the students.

Programme Structure for Bachelor of Engineering (Computer Engineering)

Please refer to Section R2 of Part II of this bulletin for details.

3.2.2   Advanced Placement Credits and Exemptions

Students who are holders of GCE 'A' Levels, International Baccalaureate or equivalent qualifications* may be granted advanced placement and exemption of up to 20 MCs for Programme requirements based on performance in placement tests set by the relevant host faculty. The placement test should be taken at the point of admission to the University. SoC students can apply to sit for a placement test for CS1010 Programming Methodology if they have prior programming experience.

Polytechnic Graduates admitted to School of Computing

Polytechnic graduates who are admitted to NUS Computing Courses may receive up to 40 MCs of module exemptions from the following lists:

1. Specific exemptions of up to 20 MCs from programme requirements* comprising of one or more modules as determined by the School on a case-by-case basis. Some of these exemptions may require advance placement test.
2. Up to 20 MCs from Unrestrictive Elective Modules (UEMs). The 20 MCs from UEM will NOT be counted as part of the 60-MC limit of level-1000 modules that students are allowed to read in fulfillment of the 160 MCs required for graduation.

*Note:

1. The advanced placement of 20 MCs is equivalent to one semester of advanced standing.
2. The validity period for qualifications presenting for the granting of advanced placement credits is 5 years at the point of admission.

3.2.3   Workload

Students must have a workload of at least 18 MCs per semester, except in their graduating semester. Students who fail to sign up for tutorial/laboratory/recitations for their module(s) will be automatically withdrawn from class. The maximum workload permissible per semester will be subjected to approval by the University and home faculty. For the first semester of study, single degree students can sign up no more than 23 MCs. Students doing double degree or concurrent degree programmes can sign up for 6 modules (and not exceeding 27 MCs) in their first semester of study.

3.2.4   Continual Assessment

Continual assessment (CA) will be taken into account and it normally contributes to between 40% and 100% of the final grade of a module unless otherwise stated by the department. Homework, quizzes, tests, practicals, essays, projects, seminar presentations, performance during tutorials, field trips and other project work are bases for continual assessment.

3.2.5   Leave of Absence

Students who require leave of one semester or more should obtain approval in advance of the semester. They should first consult their academic advisors to understand the implications involved. Students must submit an online application via myISIS. Supporting documents must be attached with the application. For medical leave, students must submit the original copy of the medical certificates issued by registered general practitioners to the respective offices, by the next working day for the period of medical leave taken. For students in a Bachelor of Computing programme or Bachelor of Science in Business Analytics programme, all supporting documents must be submitted to the Office of Undergraduate Studies, School of Computing (COM1 #02-19). For students in

Bachelor of Engineering (Computer Engineering) programme, all supporting documents must be submitted to Department of Electrical and Computer Engineering, Faculty of Engineering (E4-05-45). Students who apply for term leave of absence beyond Instructional Week 2 are liable to pay fees for the entire semester. <u>Not having attended any classes nor utilizing university's resources are not valid reasons to seek waiver from fee payment</u>. Students who are granted leave before the end of the 2nd Instructional Week will have their modules removed from the records. Those granted leave due to medical reason beyond the 2nd Instructional Week will have Incomplete (IC) grades assigned to their modules. For LOA due to non-medical reason, Withdrawn (W) grades will be assigned to their modules. Students should apply for Special Consideration from examination instead if their application for term LOA starts from Reading week.

3.2.6　　Bachelor of Computing in Computational Biology

Overview

The main objective of this programme is to provide a multidisciplinary education, to produce graduates who would be equally at ease with algorithm design and mathematical and statistical analysis as they would be with biochemistry, biology/genetics, and wet-lab know-how. Besides an opportunity to pursue a career in IT, graduates from the programme will also be equipped for a career in the fast-paced pharmaceutical, biomedical or biotechnology industries. This will help meet the demand of the local market for talents with such skill sets. Moreover, the breadth of instructions will pave the way for good students to pursue graduate studies in Bioinformatics.

Programme Structure

The programme is structured such that both Computing and Faculty of Science students share a common core multidisciplinary curriculum (lower division) in their first two years of study.

The <u>lower division</u> embraces a fundamental body of knowledge in which a computational biologist should be proficient. This body of knowledge consists of the following:

- Discrete mathematics and combinatorics, i.e., logic, sets, graphs, counting techniques, etc.;
- Probability and statistics, i.e., sample spaces, random variables, conditioning, distributions, design of experiments, significance tests, statistical inference, etc.;
- Algorithm design and proficiency in some current programming language, i.e., combinatorial algorithms, algorithmic paradigms, analysis and design, working knowledge of current languages (for example, C, C++, Java) and experience in writing actual nontrivial code;
- Organic chemistry and biochemistry;
- Biology and genetics, including a moderate amount of wet-lab experience.

The <u>upper division</u> specialised track trains students in algorithmic design to facilitate the design of computationally efficient software and tools in both centralised and networking environments. Students in this track will pick up skills in software engineering, networking and advanced techniques in algorithmic design. Students may also take modules from the Computational Biology elective list.

Degree Requirements

The Computational Biology programme degree requires at least 160 MCs. Modules are classified as follows (note that every module can only be counted towards satisfying exactly one requirement):

Students will be required to satisfy 12 MCs of industrial experience (mandatory requirement) by doing:

1. A 6-month internship through CP3880 Advanced Technology Attachment Programme (12 MCs)
2. Two 3-month internships through CP3200 Internship (6 MCs) and CP3202 Internship II (6 MCs). With two internships, the student will be able to experience work in two distinct types of organizations, such as a start-up and a MNC, or in two different industries.
3. IS4010 Industry Internship Programme (12 MCs) from the IS department.
4. A 3-month internship through CP3200 Internship (6 MCs) and an Industry Course (4 MCs)[1]. The remaining 2 MCs may be satisfied using Unrestricted Electives.
5. iLead (16 MCs) or NOC (32 MCs)[2].
6. Other forms of industry experience approved by the Department of Computer Science.

1. **PROGRAMME REQUIREMENTS (Total of 124 MCs)**

Common Essentials

CS1010   Programming Methodology[3]
CS1020   Data Structures and Algorithms I[4]
CS2010   Data Structures and Algorithms II[4]
CS2100   Computer Organisation
CS2102   Database Systems
CS2103T Software Engineering[5]
CS2105   Introduction to Computer Networks

Major Requirements
Level-1000
CM1401 Chemistry for Life Sciences
CS1231   Discrete Structures
LSM1101 Biochemistry and Biomolecules
LSM1102 Molecular Genetics
MA1101R Linear Algebra I
MA1521 Calculus for Computing

Level-2000
CS2220 Introduction to Computational Biology
CS2101 Effective Communication for Computing Professionals

Either
LSM2101 Metabolism and Regulation
or
LSM2102 Molecular Biology
or
LSM2103 Cell Biology

LSM2241   Introductory Bioinformatics
ST2334   Probability and Statistics[6]

Level-3000
CS3230   Design & Analysis of Algorithms
LSM3231   Protein Structure and Function

Either
CS3225   Combinatorial Methods in Bioinformatics
or
MA3259   Mathematical Methods in Genomics

Minimum of 12 MCs from the following list[7]:
CS3103   Computer Networks Practice

Either:
CS3225   Combinatorial Methods in Bioinformatics
or
MA3259   Mathematical Methods in Genomics

CS3240   Interaction Design
CS3241   Computer Graphics
CS3243   Introduction to Artificial Intelligence
CS3244   Machine Learning

Level-4000

CS4220   Knowledge Discovery Methods in Bioinformatics
LSM4241   Functional Genomics
CP4101   B. Comp. Dissertation[8] or Industrial Experience Requirement (12 MCs)
Complete 8 MCs by taking modules from CB Elective Course List

Computational Biology (CB) Elective Course List[9]

CS4221   Database Applications Design and Tuning
CS4231   Parallel and Distributed Algorithms
CS4234   Optimisation Algorithms
CS4235   Computational Geometry
CS4237   Systems Modelling and Simulation
CS4243   Computer Vision and Pattern Recognition
CS4244   Knowledge-Based Systems
CS4248   Natural Language Processing
CS5228   Knowledge Discovery and Data Mining
CS5234   Combinatorial & Graph Algorithms
CS5238   Advanced Combinatorial Methods in Bioinformatics
CS5340   Uncertainty Modelling in Artificial Intelligence

2. **UNIVERSITY LEVEL REQUIREMENTS**

As specified in Section 3.2.1.

3. **UNRESTRICTED ELECTIVES**

As specified in Section 3.2.1.

NUS Overseas Colleges (NOC) (Computational Biology)

Students who attend 1-year NUS Overseas Colleges (NOC) may:

1. Count TR3201 Entrepreneurship Practicum (8 MCs) towards computational biology electives.
2. Count TR3202 Start-up Internship Programme (12 MCs) towards Industrial Experience Requirement.
3. Count TR3203E Start-up Case Study and Analysis (8 MCs) towards level-3000 electives. Students should work on a computational biology-related project to take TR3203E. Otherwise, students should take TR3203 instead (which counts towards Unrestricted Electives).

Students who attend 6-month NUS Overseas Colleges (NOC) may:

1. Count TR3202 Start-up Internship Programme (12 MCs) towards Industrial Experience Requirement.
2. Count TR3203E Start-up Case Study and Analysis (8 MCs) towards one level-3000 elective (4 MCs). The remaining 4 MCs counts towards Unrestricted Electives. Students should work on a computational biology-related project to take TR3203E. Otherwise, students should take TR3203 instead (which counts 8 MCs towards Unrestricted Electives).

University Scholars Programme (Computational Biology)

Students in the University Scholars Programme (USP) who choose the Bachelor of Computing (Computational Biology) major will take the Computational Biology programme, but with the following variations:

1. They will not be required to read University Level Requirements (20 MCs). These are replaced by 3 USP Inquiry Modules and 2 USP Foundation modules (Quantitative Reasoning Foundation and University Scholars Seminar).
2. They will not be required to read CS2101 Effective Communication for Computing Professionals. It is replaced by USP Foundation module: Writing and Critical Thinking.
3. With the special permission from the UROP coordinator and Computational Biology Programme Coordinator, they will read CP3208/CP3209 Undergraduate Research in Computing I/II with a project on computational biology as independent study modules (ISMs), which will be counted as 2 USP Inquiry modules in Sciences and Technologies Basket.
4. They will further complete 3 more USP Inquiry modules (for a total of 8 USP Inquiry modules, including CP3208 and CP3209) and the USP Reflection module (the Senior Seminar). They will have no MCs under the Unrestricted Electives.

Table 1: Summary of degree requirements for B.Comp. (Computational Biology)

Modules	MCs	Subtotals

UNIVERSITY LEVEL REQUIREMENTS		**20**
PROGRAMME REQUIREMENTS		**124**
Common Essentials		.
CS1010 Programming Methodology[11]	4	
CS1020 Data Structures and Algorithms I[12]	4	
CS2010 Data Structures and Algorithms II[12]	4	
CS2100 Computer Organisation	4	
CS2102 Database Systems	4	
CS2103T Software Engineering[13]	4	
CS2105 Introduction to Computer Networks	4	
Major Requirements		
Level-1000 CS and LS major requirements		
CM1401 Chemistry for Life Sciences	4	
CS1231 Discrete Structures	4	
LSM1101 Biochemistry and Biomolecules	4	
LSM1102 Molecular Genetics	4	

MA1101R Linear Algebra I	4	
MA1521 Calculus for Computing	4	
Level-2000 CS and LS major requirements		
CS2220 Introduction to Computational Biology	4	
CS2101 Effective Communication for Computing Professionals	4	
LSM2101 Metabolism and Regulation or LSM2102 Molecular Biology or LSM2103 Cell Biology	4	
LSM2241 Introductory Bioinformatics	4	
ST2334 Probability and Statistics[14]	4	
Level-3000 CS and LS major requirements		
CS3230 Design & Analysis of Algorithms	4	
CS3225 Combinatorial Methods in Bioinformatics or MA3259 Mathematical Methods in Genomics	4	
LSM3231 Protein Structure and Function	4	
Level-3000 Electives[15]; Choose any three from the following:		
CS3103 Computer Networks Practice		

CS3225 Combinatorial Methods in Bioinformatics or MA3259 Mathematical Methods in Genomics CS3240 Interaction Design CS3241 Computer Graphics CS3243 Introduction to Artificial Intelligence CS3244 Machine Learning	12	
Level-4000 CS and LS major requirements		
CS4220 Knowledge Discovery Methods in Bioinformatics	4	
LSM4241 Functional Genomics	4	
Industrial Experience Requirement	12	
8 MCs of modules from Computational Biology Electives course list below: CS4221 Database Application Design and Tuning CS4231 Parallel and Distributed Algorithms CS4234 Optimisation Algorithms CS4235 Computational Geometry CS4237 Systems Modelling and Simulation CS4243 Computer Vision and Pattern Recognition CS4244 Knowledge-Based Systems CS4248 Natural Language Processing CS5228 Knowledge Discovery and Data Mining CS5234 Combinatorial & Graph Algorithms CS5238 Advanced Combinatorial Methods in Bioinformatics CS5340 Uncertainty Modelling in Artificial Intelligence	8	
UNRESTRICTED ELECTIVES		**16**
Grand Total		**160**

same semester.

6   Students should choose ST2131 (Probability) and ST2132 (Mathematical Statistics) in place of ST2334 (Probability and Statistics) if they plan to pursue higher level statistics modules.

7   With the special permission from the UROP coordinator and Computational Biology Programme Coordinator, CP3208/CP3209 Undergraduate Research in Computing I/II can be used to replace two of the Level-3000 Computational Biology electives if the project is on Computational Biology.

8   Students in the Department of Computer Science who aim for Honours (Highest Distinction) must pass the CP4101 B.Comp. Dissertation. Students with CAP of 4.0 or higher at the end of their fifth semester of undergraduate study may opt to replace the Industry Experience Requirement by B.Comp. Dissertation (12 MCs).

9   The Computational Biology (CB) Elective Course List may be revised from time to time to include new Computational Biology electives that are introduced and approved by the Department of Computer Science.

11   CS1010 (4 MCs) can be replaced by CS1101S Programming Methodology (5 MCs).

12   CS1020 and CS2010 can be replaced by CS2020 Data Structures and Algorithms Accelerated. The remaining 2 MCs will be added to the Unrestricted Electives Requirements.

13   Students taking CS2103T Software Engineering must take CS2101 Effective Communication for Computing Professionals in the same semester.

14   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics will take ST2131 Probability and ST2132 Mathematical Statistics in place of ST2334 Probability and Statistics

15   With the special permission from the UROP coordinator and Computational Biology Programme Coordinator, CP3208/CP3209 Undergraduate Research in Computing I/II can be used to replace two of the Level- 3000 Computational Biology electives if the project is on Computational Biology.

16   Students in the Department of Computer Science who aim for high distinction must pass the CP4101 B.Comp. Dissertation. Students with CAP of 4.0 or higher at the end of their fifth semester of undergraduate study may opt to replace the Industry Experience Requirement by B.Comp Dissertation (12 MCs).

Concurrent Programme with Brown University on Computational Biology

This is a fast-track programme that allows deserving students to obtain the Bachelor of Computing (Computational Biology) from NUS and a Scientiae Magister in Computational Biology in Computer Science from Brown University within five years.

Please refer to Section R7 of Part II of this bulletin for details.

3.2.7   Bachelor of Computing in Computer Science

Overview

The Bachelor of Computing (Honours) in Computer Science or BComp (CS) programme aims to nurture students for a rewarding computing career in various industry sectors. Suitable for those who love hands-on work and keen to apply computing technologies to solve real-world problems, the programme will equip students with the critical knowledge and capacity to take on the world with confidence.

At the time of graduation, students are expected to demonstrate:

- Strong knowledge of computer science foundations and fundamentals, including (a) familiarity with common computer science themes and principles, (b) high-level understanding of systems as a whole, (c) understanding of the theoretical underpinnings of computer science and their influences in practice.
- In-depth knowledge in one or more computer science specialisations.
- Individual competence in applying sound principles and rigorous thinking to (a) analyse an application problem, (b) understand user's requirement, (c) formulate the problem in terms of computation requirements, (c) conceive novel solution ideas, (e) design appropriate solutions that meet the requirements, (f) implement the solution, (g) evaluate the effectiveness of the solution.
- Strong communication skills and ability work with, and contribute to, a multi-disciplinary team to bring a range of technologies together to develop computer systems and solutions of multi-disciplinary nature.
- Ability to engage in continuous professional development.
- Understanding of the responsibilities of an IT professional and the ethical, social,

and legal issues related to computing.

Within 3-5 years from graduation, a graduate from the programme is expected to be able to:

- Have a career as IT professional engaging in research and/or development in one or more specialisation of computer science;
- Engage in a supportive or leadership role in a multi-disciplinary, collaborative, team environment;
- Engage in continuous learning of state-of-the-art advances in computer science (including graduate studies);
- Function as an ethical, legal and socially responsible member of the society;
- Apply computing knowledge and skills to contribute positively to the betterment of society.

For a well-rounded education, students pursuing this programme will also acquire knowledge in science, including life sciences, mathematics and physics.

The Computer Science program is accredited by the Computing Accreditation Commission of ABET, http://www.abet.org

Graduates with the Bachelor of Computing (Honours) in Computer Science degree can position themselves in a large number of exciting fields of work, including project management, knowledge engineering, software architecture, web design, digital media and security consultancy.

Degree Requirements

The Bachelor of Computing (Computer Science) programme requires at least 160 MCs.

Students will be required to satisfy 12 MCs of Industrial Experience Requirement by doing:

1. A 6-month internship through CP3880 Advanced Technology Attachment Programme (12 MCs)
2. Two 3-month internships through CP3200 Internship (6 MCs) and CP3202 Internship II (6 MCs). With two internships, the student will be able to experience work in two distinct types of organizations, such as a start-up and a MNC, or in two different industries.
3. IS4010 Industry Internship Programme (12 MCs) from the IS department.
4. A 3-month internship through CP3200 Internship (6 MCs) and an Industry Course (4 MCs).[18] The remaining 2 MCs may be satisfied using Unrestricted Electives.
5. iLead (16 MCs) or NOC (32 MCs).[19]
6. Other forms of industry experience approved by the Department of Computer Science.

1. **PROGRAMME REQUIREMENTS (Total of 120 MCs)**

Computer Science Foundation

CS1010   Programming Methodology[20]

CS1020   Data Structures and Algorithms I[21]

CS1231   Discrete Structures

CS2010   Data Structures and Algorithms II[21]

CS2100   Computer Organisation

CS2103T Software Engineering[22]
CS2105 Introduction to Computer Networks
CS2106 Introduction to Operating Systems
CS3230 Design and Analysis of Algorithms

Computer Science Breadth & Depth

Complete 24 MCs of CS modules by satisfying the following conditions:

1. Satisfy at least one CS Focus Area for B.Comp. (CS) by completing 3 modules in the Area Primaries, with at least one module at level-4000 or above. Computer Science Foundation modules that appear in Area Primaries can be counted as one of the 3 modules towards satisfying a Focus Area.
2. At least 12 MCs are at level-4000 or above.

Complete at least 8 MCs of Computer Systems Team Project modules from the following pairs, or modules approved by the Department of Computer Science:

- CS3201 Software Engineering Project I and CS3202 Software Engineering Project II, or
- CS3216 Software Product Engineering for Digital Markets and CS3217 Software Engineering on Modern Application Platforms, or
- CS3281 Thematic Systems Project I and CS3282 Thematic Systems Project II, or
- CS3283 Media Technology Project I and CS3284 Media Technology Project II

Both CS3216 and CS3217 are 5-MC modules. Students who choose to take CS3216 and CS3217 will count 8-MC towards the Computer Systems Team Project requirement and 2-MC towards Unrestricted Electives. Students must take both CS3216 and CS3217 to complete the Software Engineering Team Project requirement. If a student completed only one of CS3216 and CS3217, he or she has to take another pair of modules to meet the Computer Systems Team Project requirement.

Industry Experience Requirement of at least 12 MCs

IT Professionalism

IS1103/FC/X Computing and Society
CS2101 Effective Communication for Computing Professionals

Mathematics & Sciences

MA1301/FC/X Introductory Mathematics[24]

MA1521 Calculus for Computing[25]

MA1101R Linear Algebra I

PC1221/FC/X Fundamentals of Physics I or PC1222/X Fundamentals of Physics II[27]

Either

ST2334 Probability and Statistics[27] and a Science Module[28]

or

ST2131 Probability and ST2132 Mathematical Statistics

2 Science Modules [28]

2. **UNIVERSITY LEVEL REQUIREMENTS (20 MCs)**

As specified in Section 3.2.1.

3. **UNRESTRICTED ELECTIVES (20 MCs)**

As specified in Section 3.2.1.

Computer Science Focus Areas for B.Comp. (CS)

CS modules are organised into Focus Areas of coherent modules according to technical areas of study. A CS Focus Area is satisfied by completing 3 modules from the Area Primaries, with at least one module at 4000-level or above. CS Foundation Modules (CFM) that appear in the Area Primaries can be counted as one of the 3 modules towards satisfying a Focus Area. In this case, a student has to read just two other modules in the Area Primaries to satisfy the Focus Area. Elective modules are grouped into the Focus Areas as a guide for indicating their related areas of study.

- Algorithms & Theory
- Artificial Intelligence
- Computer Security
- Computer Graphics and Games
- Database Systems
- Multimedia Information Retrieval
- Network and Distributed Systems
- Parallel Computing
- Programming Languages
- Software Engineering

Modules classified in each focus area can be found at: http://www.comp.nus.edu.sg/undergraduates/cs_cs_focusareas.html

Enrichment

Students are encouraged to read the following enrichment modules:

- CS3882   Breakthrough Ideas for Digital Markets
- CS4880   Digital Entrepreneurship

NUS Overseas Colleges (NOC) (Computer Science)

Students who attended NOC programme may:

1. count TR3201 Entrepreneurship Practicum (8 MCs) towards CS3882 Breakthrough Ideas for Digital Markets (4 MCs) and one bridging module at 4 MCs. The mapping to bridging module (MA1301/PC1221/PC1222) applies to CS students with A-level or equivalent qualifications in either Mathematics or Physics. These students replace the missing MCs for the bridging modules with unrestricted electives. Dummy CS codes CSX3741 and CSX3742 will be issued in place of MA1301 and PC1221/PC1222 respectively.
2. count TR3202 Start-up Internship Programme (12 MCs) towards Industrial Experience Requirement.
3. count TR3203 Start-up Case Study and Analysis towards Unrestricted Electives. Students working on computer systems term projects for TR3203 may seek approval to instead take TR3203P, which counts towards CS3201/2 Software Engineering

Project I/II or equivalent pairs. Alternatively, TR3203 can be mapped to TR3203E in which 8 MCs of CS-coded electives at level-3000 can be considered for the fulfilment of CS Breadth and Depth Requirements.

University Scholars Programme (Computer Science)

Students in the University Scholars Programme who choose the Bachelor of Computing (Computer Science) major will follow the Computer Science programme, but with the following variations:

1. They will not be required to read University Level Requirements (20 MCs). These are replaced by the 3 USP Inquiry Modules and 2 USP Foundation modules (Quantitative Reasoning Foundation and University Scholars Seminar).
2. They will not be required to read CS2101 Effective Communication for Computing Professionals. It is replaced by USP Foundation module: Writing and Critical Thinking
3. They will not be required to read two Science Modules (8 MCs). These are replaced by 2 USP Inquiry modules in Sciences and Technologies basket.
4. They will read UROP modules (CP3208 and CP3209) in place of CS3201 and CS3202 or CS3281 and CS3282. CP3208 and CP3209 are independent study modules (ISMs) which will also be counted as 2 USP Inquiry modules in Sciences and Technologies basket.

Table 2: Summary of degree requirements for Bachelor of Computing (Computer Science)

Modules	MCs	Subtotals
UNIVERSITY LEVEL REQUIREMENTS		**20**
PROGRAMME REQUIREMENTS		**120**
Computer Science Foundation	**36**	
CS1010 Programming Methodology	4	
CS1020 Data Structures and Algorithms I	4	
CS2010 Data Structures and Algorithms II	4	

CS1231 Discrete Structures	4
CS2100 Computer Organisation	4
CS2103T Software Engineering	4
CS2105 Introduction to Computer Networks	4
CS2106 Introduction to Operating Systems	4
CS3230 Design and Analysis of Algorithms	4
Computer Science Breadth and Depth	**44**
Complete 24 MCs of CS modules by satisfying the following conditions: 1. Satisfy at least one CS Focus Area for B.Comp.(CS) by completing 3 modules in the Area Primaries, with at least one module at level-4000 or above. Computer Science Foundation modules that appear in Area Primaries can be counted as one of the 3 modules towards satisfying a Focus Area. 2. At least 12 MCs are at level-4000 or above.	24
Complete at least 8 MCs of Computer Systems Team Project modules from the following pairs, or modules approved by the Department of Computer Science: CS3201 Software Engineering Project I and CS3202 Software Engineering Project II, or CS3216 Software Product Engineering for Digital Markets and CS3217 Software Engineering on Modern Application Platforms, or	8

CS3281 Thematic Systems Project I and CS3282 Thematic Systems Project II, or CS3283 Media Technology Project I and CS3284 Media Technology Project II	
Industrial Experience Requirement[29]	12
IT Professionalism	**8**
IS1103/FC/X Computing and Society	4
CS2101 Effective Communication for Computing Professionals	4
Mathematics and Sciences	**32**
MA1301/FC/X Introductory Mathematics[30]	4
MA1521 Calculus for Computing[31]	4
MA1101R Linear Algebra I	4
PC1221/FC/X Fundamentals of Physics I or PC1222/X Fundamentals of Physics II[32]	4
Either ST2334 Probability and Statistics[27] and a Science Module[28] or ST2131 Probability and ST2132 Mathematical Statistics[33]	8
2 Science Modules [34]	8
UNRESTRICTED ELECTIVES	**20**

Grand Total		**160**

[18]   Possible industry course includes CP3101A Global Open Source Project and other relevant courses approved by the Department of Computer Science.

[19]   For students who opt for iLead or NOC, the additional MCs beyond the 12-MCs allocated to Industry Experience Requirement should be taken from Unrestricted Electives and/or exempted modules.

[20]   CS1010 (4 MCs) can be replaced by CS1101S Programming Methodology (5 MCs).

[21]   CS1020 (4 MCs) and CS2010 (4 MCs) can be replaced by CS2020 Data Structures and Algorithms Accelerated (6 MCs). The remaining 2 MCs will be added to the Unrestricted Electives Requirements.

[22]   Students taking CS2103T Software Engineering must take CS2101 Effective Communication for Computing Professionals in the same semester.

[23]   Students in the Department of Computer Science who aim for Honours (High Distinction) must pass the CP4101 B.Comp. Dissertation. Students with CAP of 4.0 or higher at the end of their fifth semester of undergraduate study may opt to replace the Industry Experience Requirement by B.Comp Dissertation (12 MCs).

[24]   MA1301/FC/X is waived for students with A-level Mathematics. The 4 MCs gained from the waiver should be used to read another module.

[25]   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics are recommended to replace MA1521 Calculus for Computing by MA1102R Calculus.

[26]   Students who have not taken 'O'-level Physics may replace PC1221/FC/X or PC1222/X by a life-science module. PC1221/FC/X or PC1222/X is waived for students with A-level Physics. The 4 MCs gained from the waiver should be used to read another module.

[27]   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics will take ST2131 Probability and ST2132 Mathematical Statistics in place of ST2334 Probability and Statistics.

[28]   Science modules must be either Physics, Chemistry or Life-Science or Mathematics modules. Science modules must be modules from List S1 (recommended) or List S2. Please refer to: http://www.comp.nus.edu.sg/undergraduates/documents/Sciencemodules_S1_S2.pdf for the details.

[29]   Students in the Department of Computer Science who aim for Honours (Highest Distinction) must pass the CP4101 B.Comp. Dissertation. Students with CAP of 4.0 or higher at the end of their fifth semester of undergraduate study may opt to replace the Industry Experience Requirement by B.Comp Dissertation (12 MCs).

[30]   MA1301/FC/X is waived for students with A-level Mathematics. The 4 MCs gained from the waiver should be used to read another module.

[31]   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics are recommended to replace MA1521 Calculus for Computing by MA1102R Calculus.

[32]   Students who have not taken 'O'-level Physics may replace PC1221/FC/X or PC1222/X by a life-science module. PC1221/FC/X or PC1222/X is waived for students with A-level Physics. The 4 MCs gained from the waiver should be used to read another module.

[33]   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics will take ST2131 Probability and ST2132 Mathematical Statistics in place of ST2334 Probability and Statistics.

[34]   Science modules must be either Physics, Chemistry or Life-Science or Mathematics modules. Science modules must be modules from List S1 (recommended) or List S2. Please refer to:
       http://www.comp.nus.edu.sg/undergraduates/documents/Sciencemodules_S1_S2.pdf for the details.

3.2.8   Bachelor of Computing in Computer Science – von Neumann Programme

Overview

The von Neumann Programme for Bachelor of Computing (Computer Science) programme, [vNP] is one of the two special programmes in Computer Science. vNP aims to nurture students who aspire to engage in industry careers emphasising the design of complex computing systems. It is most suitable for students who love to solve complex real-world problems and develop complex computer-based systems for real-world applications. Students pursuing Bachelor of Computing (Computer Science) degree will be eligible for admission into vNP at the end of their first or second semester of studies based on their CAP and interview. Students in this programme will be assigned CS professors and industry partners as their mentors, who will help them to blend academic knowledge and industrial experience into their studies.

Degree Requirements

The von Neumann Programme requires at least 160 MCs. Students in the programme must maintain a minimum CAP of 4.00 in every semester of their studies.

Students will be required to satisfy 12 MCs of industrial experience (mandatory requirement) by doing:
a)   A 6-month internship through CP3880 Advanced Technology Attachment Programme (12 MCs)
b)   Two 3-month internships through CP3200 Internship (6MCs) and CP3202 Internship II (6 MCs). With two internships, the student will be able to experience work in two distinct types of organizations, such as a start-up and a MNC, or in two different industries.
c)   IS4010 Industry Internship Programme (12 MCs) from the IS department.
d)   A 3-month internship through CP3200 Internship (6 MCs) and an Industry Course (4 MCs)[35]. The remaining 2 MCs may be satisfied using Unrestricted Electives.
e)   iLead (16 MCs) or NOC (32 MCs)[36].
f)   Other forms of industry experience approved by the Department of Computer Science.

1. **PROGRAMME REQUIREMENTS (Total of 124 MCs)**

Computer Science Foundation

CS1010   Programming Methodology[37]

CS1020   Data Structures and Algorithms I[38]

CS1231   Discrete Structures

CS2010   Data Structures and Algorithms II[38]

CS2100   Computer Organisation

CS2103T   Software Engineering[39]

CS2105   Introduction to Computer Networks

CS2106   Introduction to Operating Systems

CS3230   Design and Analysis of Algorithms

Computer Science Breadth & Depth

Complete 24 MCs of CS modules by satisfying the following conditions:

1. Satisfy at least one vNP Focus Area by completing 3 modules in the Area Primaries, with at least one module at level-4000 or above. Computer Science Foundation modules that appear in Area Primaries can be counted as one of the 3 modules towards satisfying a Focus Area.
2. At least 12 MCs are at level-4000 or above.
3. Complete CS3219 Software Engineering Principles and Patterns

Complete at least 8 MCs of Computer Systems Team Project modules from the following pairs, or modules approved by the Department of Computer Science:

- CS3216   Software Product Engineering for Digital Markets and CS3217 Software Engineering on Modern Application Platforms, or
- CS3281   Thematic Systems Project I and CS3282 Thematic Systems Project II (with large-scale complex systems development)

Both CS3216 and CS3217 are 5-MC modules. Students who choose to take CS3216 and CS3217 will count 8-MC towards the Computer Systems Team Project requirement and 2-MC towards Unrestricted Electives. Students must take both CS3216 and CS3217 to

complete the Software Engineering Team Project requirement. If a student completed only one of CS3216 and CS3217, he or she has to take another pair of modules to meet the Computer Systems Team Project requirement.

Industry Experience Requirement of at least 12 MCs

<u>IT Professionalism</u>
IS1103/FC/X   Computing and Society
CS2101   Effective Communication for Computing Professionals

<u>Mathematics & Sciences</u>
MA1301/FC/X Introductory Mathematics[40]

MA1521   Calculus for Computing[41]
MA1101R   Linear Algebra I
PC1221/FC/X   Fundamentals of Physics I or
PC1222/X   Fundamentals of Physics II[43]

Either
ST2334 Probability and Statistics[43] and a Science module[44];
or
ST2131 Probability and ST2132 Mathematical Statistics

2 Science Modules[44]

2. **UNIVERSITY LEVEL REQUIREMENTS (20 MCs)**

As specified in Section 3.2.1.

3. **UNRESTRICTED ELECTIVES (16 MCs)**

As specified in Section 3.2.1.

vNP Focus Areas for B.Comp. (CS)

The following CS Focus Areas for B.Comp.(CS) are elected as vNP Focus Areas:

- Computer Networks
- Database Systems
- Parallel Computing
- Programming Languages
- Software Engineering
- Computer Security

Enrichment

Students are encouraged to read the following enrichment module:

- CS3882 Breakthrough Ideas for Digital Markets
- CS4880 Digital Entrepreneurship

NUS Overseas Colleges (NOC) – Computer Science – von Neumann Programme

Students who attended NOC programme may:

1. count TR3201 Entrepreneurship Practicum (8 MCs) towards CS3882 Breakthrough Ideas for Digital Markets (4 MCs) and one bridging module at 4 MCs. The mapping to bridging module (MA1301/PC1221/PC1222) applies to CS students with A-level or equivalent qualifications in either Mathematics or Physics. These students replace the missing MCs for the bridging modules with unrestricted electives. Dummy CS codes CSX3741 and CSX3742 will be issued in place of MA1301 and PC1221/PC1222 respectively.
2. count TR3202 Start-up Internship Programme (12 MCs) towards Industrial Experience Requirement.
3. count TR3203 Start-up Case Study and Analysis towards Unrestricted Electives. Students working on computer systems term projects for TR3203 may seek approval to instead take TR3203P, which counts towards CS3281/2 Thematic Systems Project I/II or equivalent pairs. Alternatively, TR3203 can be mapped to TR3203E in which 8 MCs of CS electives at level-3000 can be considered for the fulfilment of CS Breadth and Depth Requirements.

University Scholars Programme (Computer Science)

Students in the University Scholars Programme who choose the Bachelor of Computing (Computer Science) major will follow the Computer Science programme, but with the following variations:

1. They will not be required to read University Level Requirements (20 MCs). These are replaced by the 3 USP Inquiry Modules and 2 USP Foundation modules (Quantitative Reasoning Foundation and University Scholars Seminar).
2. They will not be required to read CS2101 Effective Communication for Computing Professionals. It is replaced by USP Foundation module: Writing and Critical Thinking
3. They will not be required to read two Science Modules (8 MCs). These are replaced by two USP Inquiry modules in Sciences and Technologies basket.
4. They will read CS3281 and CS3282 as independent study modules (ISMs) which will be counted as two USP Inquiry modules in Sciences and Technologies basket.

Table 3: Summary of degree requirements for Bachelor of Computing (Computer Science) – von Neumann Programme (vNP)

Modules	MCs	Subtotals
UNIVERSITY LEVEL REQUIREMENTS		**20**

Modules	MCs	Subtotals
PROGRAMME REQUIREMENTS		**124**
Computer Science Foundation	**36**	
CS1010 Programming Methodology[45]	4	
CS1020 Data Structures and Algorithms I[46]	4	
CS1231 Discrete Structures	4	
CS2010 Data Structures and Algorithms II[46]	4	
CS2100 Computer Organisation	4	
CS2103T Software Engineering[47]	4	
CS2105 Introduction to Computer Networks	4	
CS2106 Introduction to Operating Systems	4	
CS3230 Design and Analysis of Algorithms	4	
Computer Science Breadth & Depth	**48**	
CS3219 Software Engineering Principles and Patterns	4	
Complete at least 8 MCs of Computer Systems Team Project modules from one of the following		

pairs: CS3216 Software Product Engineering for Digital Markets and CS3217 Software Engineering on Modern Application Platform, or CS3281 Thematic Systems Project I and CS3282 Thematic Systems Project II (with large-scale complex system development)	8
Satisfy 1 vNP Focus Area with 3 CS modules at level-4000 or above After satisfying a vNP Focus Area, a student may choose to satisfy other CS Focus Areas.	24
CP4101 B. Comp. Dissertation[48] or Industrial Experience Requirement	12
IT Professionalism	**8**
IS1103/FC/X Computing and Society	4
CS2101 Effective Communication for Computing Professionals	4
Mathematics and Sciences	***24***
MA1301/FC/X Introductory Mathematics[49]	4
MA1521 Calculus for Computing[50]	4
MA1101R Linear Algebra I	4
PC1221/FC/X Fundamentals of Physics I or PC1222/X Fundamentals of Physics II[42]	4

.

Either ST2334 Probability and Statistics and a Science module[51], or ST2131 Probability and ST2132 Mathematical Statistics	8	
2 Science Modules[52]	8	
UNRESTRICTED ELECTIVES		**16**
Grand Total		**160**

[35]   Possible Industry Course includes CP3101A Global Open Source Project and other relevant courses approved by the Department of Computer Science.

[36]   For students who opt for iLead or NOC, the additional MCs beyond the 12-MCs allocated to Industry Experience Requirement should be taken from Unrestricted Electives and/or exempted modules

[37]   CS1010 (4 MCs) can be replaced by CS1101S Programming Methodology (5 MCs)

[38]   CS1020 and CS2010 can be replaced by CS2020 Data Structures and Algorithms Accelerated. The remaining 2 MCs will be added to the Unrestricted Electives Requirements.

[39]   Students taking CS2103T Software Engineering must take CS2101 Effective Communication for Computing Professionals in the same semester.

[40]   MA1301/FC/X is waived for students with A-level Mathematics. The 4 MCs gained from the waiver should be used to read another module.

[41]   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics are recommended to replace MA1521 Calculus for Computing by MA1102R Calculus.

[42]   Students who have not taken 'O'-level Physics may replace PC1221/FC/X or PC1222/X by a life science module. PC1221/FC/X or PC1222/X is waived for students with A-level Physics. The 4 MCs gained from the waiver should be used to read another module.

[43]   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics will take ST2131 Probability and ST2132 Mathematical Statistics in place of ST2334 Probability and Statistics.

[44]   Science modules must be either Physics, Chemistry or Life-Science or Mathematics modules. Science modules must be modules from List S1 (recommended) or List S2. Please refer to:
http://www.comp.nus.edu.sg/undergraduates/documents/Sciencemodules_S1_S2.pdf for the details.

[45]   CS1010 (4 MCs) can be replaced by CS1101S Programming Methodology (5 MCs).

[46]   CS1020 (4 MCs) and CS2010 (4 MCs) can be replaced by CS2020 Data Structures and Algorithms Accelerated (6 MCs). The remaining 2 MCs will be added to the Unrestricted Electives Requirements

[47]   Students taking CS2103T Software Engineering must take CS2101 Effective Communication for Computing Professionals in the same semester.

[48]   Students in the Department of Computer Science who aim for Honours (Highest Distinction) must pass the CP4101 B.Comp. Dissertation. Students with CAP of 4.0 or higher at the end of their fifth semester of undergraduate study may opt to replace the Industry Experience Requirement by B.Comp Dissertation (12 MCs).

[49]   MA1301/FC/X is waived for students with A-level Mathematics. The 4 MCs gained from the waiver should be used to read another module.

[50]   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics are recommended to replace

MA1521 Calculus for Computing by MA1102R Calculus.

3.2.9   Bachelor of Computing in Computer Science – Turing Programme

Overview

The Turing Programme for Bachelor of Computing (Computer Science) programme [TP] is yet another special programme in Computer Science. TP aims to nurture students who aspire to engage in pure research careers in Computing. It is most suitable for students who love to solve technically challenging problems and are able to handle theoretical and practical work. Students will be selected for admission to TP at the end of their first or second semester of studies based on their CAP and interview. Students in TP are expected to build sufficient track records by the time they graduate to gain admission into Ph.D. Programmes in top schools including SoC. Students pursuing the Bachelor of Computing (Computer Science) degree will be eligible for admission into TP at the end of their first or second semester of studies based on their CAP and interview. Students in this programme will be assigned CS professors as their mentors to help them to build their research track records.

Degree Requirements

The Turing Programme for Bachelor of Computing (Computer Science) requires at least 160 MCs. Students in the programme must maintain a minimum CAP of 4.00 in every semester of their studies.

1. **PROGRAMME REQUIREMENTS (Total of 126 MCs)**

Computer Science Foundation
CS1101S   Programming Methodology
CS1231   Discrete Structures
CS2020   Data Structures and Algorithms Accelerated
CS2100   Computer Organisation
CS2103T   Software Engineering[52]
CS2105   Introduction to Computer Networks
CS2106   Introduction to Operating Systems
CS3230   Design and Analysis of Algorithms
CS3230R   Design and Analysis of Algorithms

Computer Science Breadth & Depth
Complete 26 MCs of CS modules by satisfying the following conditions:

1. Satisfy at least one CS Focus Area for B.Comp.(CS) by completing 3 modules in the Area Primaries, with at least one module at level-4000 or above. Computer Science Foundation modules that appear in Area Primaries can be counted as one of the 3

modules towards satisfying a Focus Area.
2. At least 12 MCs are at level-4000 or above.
3. At least 2 R-modules.
4. Read CS4232 Theory of Computation[53].

Complete the following modules:

- CS2309   CS Research Methodology
- CS3281   Thematic Systems Project I (with research content)[54]
- CS3282   Thematic Systems Project II (with research content)[54]
- CP4101   B.Comp. Dissertation (with research content)

IT Professionalism
IS1103/FC/X   Computing and Society
CS2101   Effective Communication for Computing Professionals

Mathematics & Sciences
MA1301/FC/X   Introductory Mathematics[55]
MA1521   Calculus for Computing[56]
MA1101R Linear Algebra I
PC1221/FC/X Fundamentals of Physics I or PC1222/X Fundamentals of Physics II

Either
ST2334 Probability and Statistics and a Science Module[58]
or
ST2131 Probability and ST2132 Mathematical Statistics
2 Science Modules[58]

2. **UNIVERSITY LEVEL REQUIREMENTS (20 MCs)**

As specified in Section 3.2.1.

3. **UNRESTRICTED ELECTIVES (14 MCs)**

As specified in Section 3.2.1.

Enrichment

Students are encouraged to read the following enrichment modules:

- CS3882 Breakthrough Ideas for Digital Markets
- CS4880 Digital Entrepreneurship

Student Exchange Programme (SEP)

Students in this programme have the opportunity to go for exchange or internships to approved universities and laboratories overseas. The exchange or internship may include coursework or research components that can be mapped to the CS modules approved by the Department of Computer Science.

NUS Overseas Colleges (NOC) – Computer Science – Turing Programme

Students who attended NOC programme may:

1. count TR3201 Entrepreneurship Practicum (8 MCs) towards CS3882 Breakthrough Ideas for Digital Markets (4 MCs) and one bridging module at 4 MCs. The mapping to bridging module (MA1301/PC1221/PC1222) applies to CS students with A-level or equivalent qualifications in either Mathematics or Physics. These students replace the missing MCs for the bridging modules with unrestricted electives. Dummy CS codes CSX3741 and CSX3742 will be issued in place of MA1301 and PC1221/PC1222 respectively.
2. count TR3202 Start-up Internship Programme (12 MCs) towards Industrial Experience Requirement.
3. count TR3203 Start-up Case Study and Analysis towards Unrestricted Electives. Students working on computer systems term projects for TR3203 may seek approval to instead take TR3203P, which counts towards CS3281/2 Thematic Systems Project I/II. Alternatively, TR3203 can be mapped to TR3203E in which 8 MCs of CS electives at level-3000 can be considered for the fulfilment of CS Breadth and Depth Requirements.

University Scholars Programme (Computer Science)

Students in the University Scholars Programme who choose the Bachelor of Computing (Computer Science) major will follow the Computer Science programme, but with the following variations:

1. They will not be required to read University Level Requirements (20 MCs). These are replaced by the 3 USP Inquiry Modules and 2 USP Foundation modules (Quantitative Reasoning Foundation and University Scholars Seminar).
2. They will not be required to read CS2101 Effective Communication for Computing Professionals. It is replaced by USP Foundation module: Writing and Critical Thinking.
3. They will not be required to read two Science Modules (8 MCs). These are replaced by 2 USP Inquiry modules in Sciences and Technologies basket.
4. They will read UROP modules (CP3208 and CP3209) in place of CS3281 and CS3282. CP3208 and CP3209 are independent study modules (ISMs) which will also be counted as 2 USP Inquiry modules in Sciences and Technologies basket.

Table 4: Summary of degree requirements for Bachelor of Computing (Computer Science) – Turing Programme

Modules	MCs	Subtotals
UNIVERSITY LEVEL REQUIREMENTS		**20**
PROGRAMME REQUIREMENTS		**126**
Computer Science Foundation	**36**	

CS1101S Programming Methodology	5
CS1231 Discrete Structures	4
CS2020 Data Structures and Algorithms Accelerated	6
CS2100 Computer Organisation	4
CS2103T Software Engineering	4
CS2105 Introduction to Computer Networks	4
CS2106 Introduction to Operating Systems	4
CS3230 & CS3230R Design and Analysis of Alorithms	5
Computer Science Breadth & Depth	**50**
CS2309 CS Research Methodology	4
Satisfy 1 CS Focus Area, with 3 CS modules at Level - 4000 or above, with 2 R-modules, with CS4232 Theory of Computation	26
CS3281 Thematic Systems Project I (with research content)	4
CS3282 Thematic Systems Project II (with research content)	4
CP4101 B.Comp. Dissertation (with research	12

content)		
IT Professionalism	**8**	
IS1103/FC/X Computing and Society	4	
CS2101 Effective Communication for Computing Professionals	4	
Mathematics and Sciences	**32**	
MA1301/FC/X Introductory Mathematics[59]	4	
MA1521 Calculus for Computing[60]	4	
MA1101R Linear Algebra I	4	
Either ST2334 Probability and Statistics and a Science Module[62] or ST2131 Probability and ST2132 Mathematical Statistics	8	
PC1221/FC/X Fundamentals of Physics I or PC1222/X Fundamentals of Physics II	4	
2 Science Modules[62]	8	
UNRESTRICTED ELECTIVES		**14**
Grand Total		**160**

52   Students taking CS2103T Software Engineering must take CS2101 Effective Communication for Computing Professionals in the same semester.

53   CS4232 can be counted towards satisfying Algorithms & Theory Focus Area.

54   CS3281 and CS3282 may be replaced by CP3208 and CP3209 Undergraduate Research in Computing I and II with approval of Department of Computer Science.

55   MA1301/FC/X is waived for students with A-level Mathematics. The 4 MCs gained from the waiver should be used to read another module.

56   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics are recommended to replace MA1521 Calculus for Computing by MA1102R Calculus.

57   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics will take ST2131 Probability and ST2132 Mathematical Statistics in place of ST2334 Probability and Statistics.

58   Science modules must be either Physics, Chemistry or Life-Science or Mathematics modules. Science modules must be modules from List S1 (recommended) or List S2. Please refer to:

http://www.comp.nus.edu.sg/undergraduates/documents/Sciencemodules_S1_S2.pdf for the details.

59   MA1301/FC/X is waived for students with A-level Mathematics. The 4 MCs gained from the waiver should be used to read another module.

60   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics are recommended to replace MA1521 Calculus for Computing by MA1102R Calculus.

61   Students pursuing a double degree in Computer Science and Mathematics/Applied Mathematics will take ST2131 Probability and ST2132 Mathematical Statistics in place of ST2334 Probability and Statistics

62   Science modules must be either Physics, Chemistry or Life-Science or Mathematics modules. Science modules must be modules from List S1 (recommended) or List S2. Please refer to:

http://www.comp.nus.edu.sg/undergraduates/documents/Sciencemodules_S1_S2.pdf for details.

3.2.10   Bachelor of Computing in Information Security

Objective

The Bachelor of Computing in Information Security aims to:

- To provide a broad-based, inter-disciplinary information security undergraduate programme within NUS
- To contribute to the national focus on growing the pool of cyber security professionals in Singapore.
- To produce graduates who are able to understand information security issues and practices from both technical and organisational points of view.

Graduates of this programme are expected to have possible career choices as software engineers, systems administrators, malware researchers, security analyst, cybersecurity incident responder, and security consultant. They are expected to find employment in industries that deal with sensitive information (e.g., banks, insurance, defence), government organisations (e.g., CSIT, DSO, DSTA, MHA, Cyber Security Agency) and firms that provide security consultation/systems/services (e.g., Symantec, FireEye).

This programme enables students to attain, by the time of graduation:

i. Strong knowledge of computer science foundations and fundamentals, including (a) familiarity with common computer science themes and principles, (b) high-level understanding of systems as a whole, (c) understanding of the theoretical underpinnings of computer science and their influences in practice.

ii. An ability to design, implement, and evaluate a computer-based system, process, components, or program to meet the security needs.
iii. An understanding of the processes and challenges that support the delivery and management of information security in an organisation.
iv. An ability to function effectively in teams to accomplish a common goal.
v. An understanding of professional, ethical, legal, security, and social issues and responsibilities.
vi. An ability to communicate effectively with a range of audiences
vii. An ability to analyse the local and global impact of computing on individuals, organisations, and society.
viii. Recognition of the need for and an ability to engage in continuing professional development
ix. An ability to use the current techniques, skills, and tools necessary for information security practice.

Degree Requirements

The Bachelor of Computing (Information Security) requires at least 160 MCs.

Students will be required to satisfy 12 MCs of industrial experience (mandatory requirement) by doing:

a. A 6-month internship through CP3880 Advanced Technology Attachment Programme (12 MCs)
b. Two 3-month internships through CP3200 Internship (6 MCs) and CP3202 Internship II (6 MCs). With two internships, the student will be able to experience work in two distinct types of organisations, such as a start-up and a MNC, or in two different industries.
c. IS4010 Industry Internship Programme (12 MCs) from the IS department.
d. A 3-month internship through CP3200 Internship (6 MCs) and an Industry Course (4 MCs)[63]. The remaining 2 MCs may be satisfied using Unrestricted Electives.
e. iLead (16 MCs) or NOC (32 MCs)[64].
f. Other forms of industry experience approved by the Department of Computer Science.

1. **PROGRAMME REQUIREMENTS (Total of 126 MCs)**

Computing Foundation
CS1010   Programming Methodology
CS1020   Data Structures and Algorithms
CS1231   Discrete Structures
CS2010   Data Structures and Algorithms I
CS2100   Computer Organisation
CS2102   Database Systems
CS2103T   Software Engineering[65]
CS2105   Introduction to Computer Networks
CS2106   Introduction to Operating Systems
CS3230   Design and Analysis of Algorithms

Information Security Requirements
CS2107   Introduction to Information Security
CS3235   Introduction to Computer Security
CS3205   Information Security Capstone Project

IS4231   Information Security Management
Complete 16 MCs from the following list of modules:

    CS4236   Cryptography Theory and Practice
    CS4238   Computer Security Practices
    CS4239   Software Security
    CS5231   Systems Security
    CS5321   Network Security
    CS5322   Database Security
    CS5331   Web Security
    IS4204   IT Governance
    IS4232   Topics in Information Security Management
    IS4233   Legal Aspects of Information Technology
    IS4234   Control and Audit of Information Systems
    Other modules approved by the SoC UG Office

Computing Breadth
Complete 8 MCs of CP-coded, CS-coded or IS-coded modules at level-3000 or above.
Industrial Experience Requirement

IT Professionalism
IS1103/FC/X   Computing and Society
CS2101   Effective Communication for Computing Professionals

Mathematics
MA1101R Linear Algebra I
MA1521   Calculus for Computing
ST2334   Probability and Statistics

2. **UNIVERSITY LEVEL REQUIREMENTS (20 MCs)**

As specified in Section 3.2.1.

3. **UNRESTRICTED ELECTIVES (14 MCs)**

As specified in Section 3.2.1.

NUS Overseas Colleges (NOC) – Information Security

Students who attended NOC programme may :

1. count TR3201 Entrepreneurship Practicum (8 MCs) towards Computing Breadth.
2. count TR3202 Start-up Internship Programme (12 MCs) towards Industrial Experience Requirement.
3. count TR3203 Start-up Case Study and Analysis towards Unrestricted Electives. Students working on information security-related projects for TR3203 may seek approval to instead take TR3203P, which counts towards CS3205 Information Security Capstone Project requirement.

University Scholars Programme (Information Security)

Students in the University Scholars Programme who choose the Bachelor of Computing (Information Security) major will take the Information Security programme, but with the following variations:

1. They will not be required to read University Level Requirements (20 MCs). These are replaced by 3 USP Inquiry Modules and 2 USP Foundation modules (Quantitative Reasoning Foundation and University Scholars Seminar).
2. They will not be required to read CS2101 Effective Communication for Computing Professionals. It is replaced by USP Foundation module: Writing and Critical Thinking.
3. They will read CS3205 Information Security Capstone Project, which is an 8-MCs independent study modules (ISMs) which will be counted as 2 USP Inquiry modules in Sciences and Technologies Basket.
4. They will further complete 3 more USP Inquiry modules (for a total of 8, including CS3205) and the USP Reflection module (the Senior Seminar). They will have 4 MCs under the Unrestricted Electives.

Table 4: Summary of degree requirements for B.Comp. (Information Security)

MODULES		MCS	SUBTOTALS
UNIVERSITY LEVEL REQUIREMENTS			**20**
PROGRAMME REQUIREMENTS			**120**
Computing Foundation		**44**	
CS1010	Programming Methodology [66]	4	
CS1020	Data Structures and Algorithms I [67]	4	
CS1231	Discrete Structures	4	
CS2010	Data Structures and Algorithms II [67]	4	
CS2100	Computer Organisation	4	
CS2102	Database Systems	4	

CS2103T	Software Engineering	4
CS2105	Introduction to Computer Networks	4
CS2106	Introduction to Operating Systems	4
CS3230	Design and Analysis of Algorithms	4
IS1105	Strategic IT Applications	4
Information Security Requirements		**36**
CS2107	Introduction to Information Security	4
CS3205	Information Security Capstone Project	8
CS3235	Introduction to Computer Security	4
IS4231	Information Security Management	4
Programme Electives Complete 16 MCs from the following list of modules: CS4236 Cryptography Theory and Practice CS4238 Computer Security Practices CS4239 Software Security CS5231 Systems Security CS5321 Network Security CS5322 Database Security CS5331 Web Security IS4204 IT Governance IS4232 Topics in Information Security Management IS4233 Legal Aspects of Information Technology IS4234 Control and Audit of Information Systems Other modules approved by the SoC UG Office		**16**
Computing Breadth		**20**

Complete 8 MCs of CP-coded, CS-coded or IS-coded modules at level-3000 or above.	8	
Industrial Experience Requirement	12	
IT Professionalism	**8**	
IS1103/FC/X Computing and Society	4	
CS2101 Effective Communication for Computing Professionals	4	
Mathematics	**12**	
MA1101R Linear Algebra I	4	
MA1521 Calculus for Computing	4	
ST2334 Probability and Statistics	4	
UNRESTRICTED ELECTIVES[68]		**20**
Grand Total		**160**

63   Possible Industry Course includes CP3101A Global Open Source Project and other relevant courses approved by the Department of Computer Science.

64   For students who opt for iLead or NOC, the additional MCs beyond the 12-MCs allocated to Industry Experience Requirement should be taken from Unrestricted Electives and/or exempted modules.

65   Students taking CS2103T Software Engineering must take CS2101 Effective Communication for Computing Professionals in the same semester.

66   CS1010 can be replaced by CS1101S Programming Methodology.

67   CS1020 and CS2010 can be replaced by CS2020 Data Structures and Algorithms Accelerated. The remaining 2 MC will be added to the Unrestricted Electives Requirements.

68   Students without A-level mathematics are required to complete MA1301 or MA1301X Introductory Mathematics as part of the UE.

3.2.11   Bachelor of Computing in Electronic Commerce

Objective

The four-year joint E-Commerce programme (EC) is offered by School of Computing (SoC) and School of Business (BIZ). The programme will have a mix of Information Technology (IT) and Business knowledge areas.

Graduates of the EC programme will be in demand by companies in the E-Business space - an area which large companies cannot ignore in today's new media age. E-Commerce students will develop into experts on Internet business. They will learn the basics of e-commerce, such as accounting, marketing, e-payment and e-economy, social computing, web forums and social networks, web user characteristics, e-loyalty and e-migration, and Internet technology. Students will become strategists in analysing and influencing e-commerce, such as web traffic, web opinion, virtual markets, virtual economy, electronic word of mouth, collaborative mobile and social e-commerce. Typical jobs include e-commerce entrepreneurship, online marketing, web design, web analysis, and web consultancy.

University Scholars Programme (E-Commerce)

Students in the University Scholars Programme who choose the Bachelor of Computing (E-Commerce) major will take the E-Commerce programme, but with the following variations:

1. They will not be required to read University Level Requirements (20 MCs). These are replaced by the 3 USP Inquiry Modules and 2 USP Foundation modules (Quantitative Reasoning Foundation and University Scholars Seminar).
2. They will not be required to read IS2101 Business and Technical Communication. It is replaced by USP Foundation module: Writing and Critical Thinking.
3. They will have 8 (instead of 20) MCs under Unrestricted Electives.
4. They will read UROP modules (CP3208 and CP3209) in place of the EC team project module (IS4102). CP3208 and CP3209 are independent study modules (ISMs) which will be counted as 2 USP Inquiry modules in Sciences and Technologies Basket.
5. They will be required to take 44 MCs (11 modules) from the Programme Electives. Among these modular credits, at least 12 MCs (3 modules) must be at level-4000.

Table 5: Summary of degree requirements for B.Comp. (E-Commerce)

Modules	MCs	Sub totals
UNIVERSITY LEVEL REQUIREMENTS		**20**
PROGRAMME REQUIREMENTS		**120**

Core Modules		*60*	
CS1010J	Programming Methodology	4	
CS1020I	Data Structures and Algorithms	4	
IS1103FC	Computing and Society	4	
IS1105	Strategic IT Applications	4	
IS1112FC	E-Business Essentials	4	
IS2101	Business and Technical Communication	4	
IS2150	E-Business Design and Implementation	4	
CS3240	Interaction Design	4	
IS3230	Principles of Information Security	4	
IS3150	Digital and New Media Marketing	4	
IS4150	Mobile and Ubiquitous Commerce	4	
IS4102	E-Business Capstone Project	8	
IS4260	E-Commerce Business Models	4	

ST1131 Introduction to Statistics	4	
Programme Electives (PE)	**48**	

Students are required to choose 2 out of the 4 modules in this list:
 	
    CS4880   Digital Entrepreneurship
 	
    IS3220   Service Science
 	
    IS3240   Economics of E-Business
 	
    IS3241   Enterprise Social Systems
	8
	
	(All modules are 4 MCs).	

Students are required to choose 3 modules from this list of School of Business modules:
 	
    ACC1002X   Financial Accounting
 	
    ACC2002   Managerial Accounting
 	
    <u>BSP1004X   Legal Environment of Business</u>
 	
    <u>BSP1005X   Managerial Economics</u>
 	
    DSC2006   Operations Management
 	
    DSC3201   Supply Chain Management
 	
    FIN2004   Finance
 	
    MNO1001X Management and Organisation
 	
    MKT1003X   Principles of Marketing
 	
    MKT2412   Global Marketing
 	
    TR2201   Entrepreneurial Marketing
 	
    TR2202   Technological Innovation
 	
    TR3001   New Product Development
	12
	
	(All modules are 4 MCs).	

<u>Programme Electives</u>		

Option 1:

Choose 7 modules from the Programme Elective List below to make up 28 MCs. 3 of the 7 modules must be at level-4000.

Option 2:

Choose CP4101 and 4 modules from Programme Elective List below to make up 28 MCs.

CP4101   B.Comp. Dissertation

Programme Elective List

CS3235   Computer Security

IS3221   Enterprise Resource Planning Systems

IS3222   IT and Customer Relationship Management

IS3223   IT and Supply Chain Management

IS3242   Software Quality Management

IS3243   Technology Strategy and Management

IS3250   Health Informatics

IS3260   Gamification for Organisations and Individuals

IS3261   Mobile Apps Development

IS4224   Service Systems

IS4225   Strategic IS Planning

IS4226   IT Outsourcing and Offshoring Management

IS4227   Enterprise Service Oriented Architecture

IS4228   Information Technologies in Financial Services

IS4231   Information Security Management

28

All modules are 4 MCs modules, except CP4101 (12 MCs)

IS4232 Topics in Information Security Management		
IS4233 Legal Aspects of Information Technology		
IS4234 Control and Audit of Information Systems		
IS4240 Business Intelligence Systems		
IS4241 Social Media Network Analysis		
IS4243 Information Systems Consulting		
IS4250 Healthcare Analytics		
IS4010 Industry Internship Programme[64]	12	
UNRESTRICTED ELECTIVES[65]		20
Grand Total		160

64   Students can choose to take on any current 12 MCs or more internship-related programmes within the School of Computing (e.g., CP3880 Advanced Technology Attachment Programme (ATAP)) and/or within NUS (e.g., Innovative Local Enterprise Achiever Development (iLEAD) and NUS Overseas College (NOC)) in place of IS4010 Industry Internship Programme to satisfy the industry experience requirement.
65   Students are encouraged to use their unrestricted electives to take modules that will build up their business domain knowledge. Having a strong knowledge of a business domain will provide EC graduates a favourable advantage in employment opportunities in the industry.

3.2.12   Bachelor of Computing in Information Systems

Objective

The four-year IS programme will provide students with a deep appreciation of the

organisational context of ICT; strong proficiency in the design and development of value-adding infocomm solutions; and strong proficiency in the cost effective management of infocomm projects. This multidisciplinary education on information systems focuses on the application and management of information technology to enhance the effectiveness of organisations and businesses. It also analyses the impact and trends of technology and the relevant implications for the economy and society.

IS graduates will be equipped with relevant knowledge to target short- to medium-term positions such as techno-strategist, ICT solutions architect, systems integrator, business process consultant/analyst, and infocomm project manager. Possible employers include end users of ICT, system integrators, consulting firms, market research firms, regulatory agencies and investment advisors.

Specialisations

Students can also package their own specialisations by reading modules that satisfy the specialisation requirements. Specialisations provide students the opportunity to gain focused, in-depth knowledge in specialised areas where information systems are deployed.

To be awarded with specialisations, students have to complete 6 modules (24 MCs) in the list of modules included for a specialisation.

Electronic Commerce Specialisation

For the Electronic Commerce Specialisation, students have to complete three compulsory modules:

- IS3150 Digital and New Media Marketing
- IS4150 Mobile and Ubiquitous Commerce
- IS4260 E-Commerce Business Models

and choose three modules from the following elective modules:

- IS3240 Economics of E-Business
- IS3241 Enterprise Social Systems
- IS3243 Technology Strategy and Management
- IS3222 IT and Customer Relationship Management
- IS3261 Mobile Apps Development for Enterprise
- IS4225 Strategic IS Planning
- IS4228 Information Technologies in Financial Services

NUS Overseas Colleges (NOC) – Information Systems

Students who attended NOC programme may :

1. count TR3201 Entrepreneurship Practicum (8 MCs) partially in lieu of CP4101 BComp Dissertation (4 out of 12 MCs) and replace one IS programme elective at level-3000 (4 MCs).
2. count TR3202 Start-up Internship Programme (12 MCs) towards Industrial Experience Requirement (i.e. IS4010 Industry Internship Programme).
3. count TR3203 Start-up Case Study and Analysis (8 MCs) partially in lieu of CP4101 B.Comp Dissertation (8 out of 12 MCs).

University Scholars Programme (Information Systems)

Students in the University Scholars Programme who choose the Bachelor of Computing (Information Systems) major will take the IS programme, but with the following variations:

1. They will not be required to read University Level Requirements (20 MCs). These are replaced by the 3 USP Inquiry Modules and 2 USP Foundation modules (Quantitative Reasoning Foundation and University Scholars Seminar).
2. They will not be required to read IS2101 Business and Technical Communication. It is replaced by USP Foundation module: Writing and Critical Thinking.
3. They will have 8 (instead of 20) MCs under Unrestricted Electives
4. They will read UROP modules (CP3208 and CP3209) in place of the IS team project module (IS3102). CP3208 and CP3209 are independent study modules (ISMs) which will be counted as 2 USP Inquiry modules in Sciences and Technologies Basket.
5. They will be required to take 24 MCs (6 modules) from the Programme Electives. Among these modular credits, at least 12 MCs (3 modules) must be at level-4000.

Table 6: Summary of degree requirements for B.Comp. (Information Systems)

Modules	MCs	Sub totals
UNIVERSITY LEVEL REQUIREMENTS Please refer to Section 3.2.1.		**20**
PROGRAMME REQUIREMENTS		**120**
Core Modules	**80**	
CS1010J Programming Methodology	4	
CS1020I Data Structures and Algorithms	4	
CS1231 Discrete Structures	4	
IS1103/FC/X Computing and Society	4	

IS1105 Strategic IT Applications	4	
IS2101 Business and Technical Communication	4	
ACC1002X Financial Accounting	4	
CS2100 Computer Organisation	4	
CS2102 Database Systems	4	
CS2105 Introduction to Computer Networks	4	
IS2102 Requirements Analysis and Design	4	
IS2103 Enterprise Systems Development Concepts	4	
IS2104 Software Team Dynamics	4	
IS3101 Management of Information Systems	4	
IS3102 Enterprise Systems Development Project	8	
IS4100 IT Project Management	4	
MA1301/FC/X Introductory Mathematics[69]	4	
MA1521 Calculus for Computing		

or		4	
MA1312	Calculus with Applications[70]		
ST2334	Probability and Statistics	4	
Programme Electives (PE)		**24**	

Option 1:

Choose 7 modules to make up 28 MCs from the list of Programme Electives below. 3 of the 7 modules must be at level-4000.

Option 2:

Choose CP4101 and 4 modules to make up 28 MCs from the list of Programme Electives below.

CP4101   B.Comp. Dissertation

Programme Elective List

CS2106   Introduction to Operating Systems

CS2107   Introduction to Information Security

CS3235   Computer Security

CS3240   Interaction Design

IS3150   Digital and New Media Marketing

IS3220   Service Science

IS3221   Enterprise Resource Planning Systems

IS3222   IT and Customer Relationship Management

IS3223   IT and Supply Chain Management

IS3230   Principles of Information Security

IS3240	Economics of E-Business		
IS3241	Enterprise Social Systems		
IS3242	Software Quality Management		
IS3243	Technology Strategy and Management		
IS3250	Health Informatics		
IS3260	Gamification for Organisations and Individuals		
IS3261	Mobile Apps Development for Enterprise		
CS4880	Digital Entrepreneurship		
IS4150	Mobile and Ubiquitous Commerce		
IS4202	Global Virtual Project		
IS4203	IT Adoption and Change Management		
IS4204	IT Governance	All modules are 4 MCs modules, except CP4101 (12 MCs)	
IS4224	Service Systems		
IS4225	Strategic IS Planning		
IS4226	IT Outsourcing and Offshoring Management		
IS4227	Enterprise Service-Oriented Architecture		
IS4228	Information Technologies in Financial Services		
IS4231	Information Security Management		
IS4232	Topics in Information Security Management		
IS4233	Legal Aspects of Information Technology		
IS4234	Control and Audit of Information Systems		
IS4240	Business Intelligence Systems		

IS4241 Social Media Network Analysis		
IS4243 Information Systems Consulting		
IS4250 Healthcare Analytics		
IS4260 E-Commerce Business Models		

To be awarded the **Electronic Commerce Specialisation**, students have to satisfy the following:
 	
    Compulsory modules:
 	
        IS3150   Digital and New Media Marketing
 	
        IS4150   Mobile and Ubiquitous Commerce
 	
        IS4260   E-Commerce Business Models
 	
and choose three modules from the following elective modules:
 	
 IS3222   IT and Customer Relationship Management
 	
 IS3240   Economics of E-Business
 	
 IS3241   Enterprise Social Systems
 	
 IS3243   Technology Strategy and Management
 	
 IS3261   Mobile Apps Development for Enterprise
 	
 IS4225   Strategic IS Planning
 	
 IS4228 Information Technologies in Financial Services		

IS4010 Industry Internship Programme[71]	12	
Unrestricted Electives[72]		20
Grand Total		160

69   MA1301/FC/X is waived for students with A-level Mathematics. The 4 MCs gained from the waiver are added to the MCs for Unrestricted Electives. Students on double degree programmes who possess A-level Mathematics or its equivalent are not required to replace the missing MCs for MA1301 with unrestricted electives.

70   MA1521 to be chosen if student wants to keep the option of switching to the Computer Science stream.

71   Students can choose to take on any current 12 MCs or more internship-related programmes within the School of Computing (e.g., CP3880 Advanced Technology Attachment Programme (ATAP)) and/or within NUS (e.g., Innovative Local Enterprise Achiever Development (iLEAD) and NUS Overseas College (NOC)) in place of IS4010 Industry Internship Programme to satisfy the industry experience requirement.

72   Students are encouraged to use their unrestricted electives to take modules that will build up their business domain knowledge. Having a strong knowledge of a business domain will provide IS graduates a favorable advantage in employment opportunity in the industry.

3.2.13   Bachelor of Science in Business Analytics

Objective

The emerging phenomena of Big Data - large pools of data sets that can be captured, communicated, aggregated, stored, and analyzed - has presented companies and organisations with trillions of bytes of information about their customers, suppliers, and operations. Millions of networked sensors are also embedded in various devices such as mobile phones and tablet computers to sense, create, and communicate data. Big data is now part of every industry sector and function of the global economy. It is increasingly the case that modern economic activity, innovation, and growth have to take place with data and the related analytic processes, methods and outputs. The discipline of business analytics (BA) enables companies and organisations to realise the full potential of data generated from various business processes, sources and devices, thus improving their speed and effectiveness in generating business insights and intelligence for optimal decision making purposes.

Programme Introduction

The Bachelor of Science (Business Analytics) degree programme is an inter-disciplinary undergraduate degree programme offered by the School of Computing with participation from the Business School, Faculty of Engineering, Faculty of Science, and Faculty of Arts and Social Sciences. This is a four-year direct honours programme which offers a common two-year broad-based inter-disciplinary curriculum where all students will read modules in Mathematics, Statistics, Economics, Accounting, Marketing, Decision Science, Industrial and Systems Engineering, Computer Science and Information Systems. Students in their third and fourth years of study may choose elective modules from two lists of either functional or methodological elective modules. Functional elective modules span business functions or sectors of marketing, retailing, logistics, healthcare, etc. Methodological elective modules include those related to big data techniques, statistics, text mining, data mining, social network analysis, econometrics, forecasting, operations research, etc. In sum, these elective modules span the most exciting and challenging areas of business analytics practice in the industry today.

Programme Learning Objectives

Learning objectives of the Bachelor of Science (Business Analytics) degree programme are:

- To understand the conceptual and methodological foundations of analytical methods and techniques for business analytics, as referenced from disciplines such as computing, engineering, science, mathematics, statistics, business and economics
- To appreciate and understand current business analytics problems in the industry worldwide and be able to identify and resolve practically relevant business analytics questions and issues
- To apply appropriate analytic tools and techniques to resolve complex business analytics problems in various industry sectors and domains
- To cultivate the practices of independent and group learning on the part of students that will prepare them to function effectively for diverse careers in business analytics

NUS Overseas Colleges (NOC) – Business Analytics

Students who attended NOC programme may:

1. count TR3201 Entrepreneurship Practicum (8 MCs) partially in lieu BT4101 BSc Dissertation (4 out of 12 MCs) and replace one Business Analytics programme elective at level-3000 (4 MCs).
2. count TR3202 Start-up Internship Programme (12 MCs) towards Industrial Experience Requirement (i.e. IS4010 Industry Internship Programme).
3. count TR3203 Start-up Case Study and Analysis (8 MCs) partially in lieu of BT4101 BSc Dissertation (8 out of 12 MCs).

University Scholars Programme (Business Analytics)

Students in the University Scholars Programme (USP) who choose the Bachelor of Science (Business Analytics) degree programme will do so with the following variations:

1. They will not be required to read IS2101 Business and Technical Communication in the Core modules requirement. It is replaced by USP Foundation module of Writing and Critical Thinking.
2. They will read the UROP module (CP3208) in place of the Business Analytics Capstone Project module (BT3101) in the Core modules requirement. CP3208 is an independent study module (ISM) which will be counted as 1 USP Inquiry module in the Sciences and Technologies domain.
3. They will not be required to read University Level Requirements (20 MCs). These are replaced by the 3 USP Inquiry modules and 2 USP Foundation modules (Quantitative Reasoning and University Scholars Seminar).
4. They will not be required to read Unrestricted Electives (20 MCs). These are replaced by the USP Reflection module of Senior Seminar and 4 USP Inquiry modules.
5. In summary, the breakdown of 12 USP modules will fit into these MCs requirement categories:
    - Core: 1 Foundation module (Writing and Critical Thinking replacing IS2101), 1 Inquiry module (CP3208/USP-ISM replacing BT3101)
    - ULR: 3 Inquiry modules and 2 Foundation modules
    - UE: 1 Reflection module and 4 Inquiry modules

Table 7: Summary of degree requirements for B.Sc. (Business Analytics)

Modules	MCs	Sub totals
UNIVERSITY LEVEL REQUIREMENTS Please refer to Section 3.2.1.		**20**
PROGRAMME REQUIREMENTS		**120**
Core Modules	**84**	
ACC1002X Financial Accounting	4	
BT1101　Introduction to Business Analytics	4	
CS1010S　Programming Methodology	4	
CS1020　Data Structures and Algorithms I	4	
EC1301　Principles of Economics[73]	4	
IS1103/FC/X　Computing and Society	4	
IS1105　Strategic IT Applications	4	
IS1112/FC/X　E-Business Essentials	4	
MA1311　Matrix Algebra and Applications, or MA1101R Linear Algebra I[74]	4	
MA1521　Calculus for Computing, or MA1102R	4	

Calculus[74]		
MKT1003X Marketing	4	
BT2101 IT and Decision Making	4	
IE2110 Operations Research I[75], or DSC3214 Introduction To Optimisation	4	
IS2101 Business and Technical Communication	4	
ST2131 Probability	4	
ST2132 Mathematical Statistics	4	
BT3101 Business Analytics Capstone Project	4	
BT3102 Computational Methods for Business Analytics	4	
DSC3215 Stochastic Models in Management	4	
IS4240 Business Intelligence Systems	4	
ST3131 Regression Analysis	4	
Programme Electives (PE)	**24**	
Option 1: Choose 6 modules to make up 24 MCs from both List A and List B, with at least 2 modules from each list. 5 of 6 modules must be at 4000 level. **Option 2:**		

Choose BT4101 and 3 modules to make up 24 MCs from both List A and List B, with at least 1 module from each list. 2 of 3 modules must be at 4000 level. BT4101 B.Sc. Dissertation <u>List A (Functional):</u> DSC3224 Dynamic Pricing and Revenue Management IE3120 Manufacturing Logistics IS3240 Economics of E-Business BT4211 Data-Driven Marketing BT4212 Search Engine Optimization and Analytics DSC4213 Analytical Tools for Consulting IS4250 Healthcare Analytics MKT4415C Seminars in Marketing: Applied Market Research <u>List B (Methodological):</u> DSC3216 Forecasting for Managerial Decisions BSP4513 Econometrics: Theory & Practical Business Application BT4221 Big Data Techniques and Technologies BT4222 Mining Web Data for Business Insights IS4241 Social Media Network Analysis IE4210 Operations Research II ST4240 Data Mining ST4245 Statistical Methods for Finance	All modules are 4MCs modules, except BT4101 (12 MCs)	
IS4010 Industry Internship Programme[76]	**12**	
UNRESTRICTED ELECTIVES		20
Grand Total		160

73   Students have done EC1101E Introduction to Economic Analysis can use it to replace EC1301.

74   Students are encouraged to take these MA module options should they wish to pursue a more rigorous treatment of the subject topics covered.

75   Students are encouraged to take IE2110 should they wish to choose IE4210 as an elective module.

76   Students can choose to take on any current 12 MCs or more internship-related programmes within the School of Computing (e.g., CP3880 Advanced Technology Attachment Programme (ATAP)) and/or within NUS (e.g., Innovative Local Enterprise Achiever Development (iLEAD) and NUS Overseas College (NOC)) in place of IS4010 Industry Internship Programme to satisfy the industry experience requirement.

3.2.14   Bachelor of Engineering in Computer Engineering

Please refer to Section R2 of Part II: Programmes of this bulletin for details.

3.3   Multidisciplinary Programmes

3.3.1   Double Degree Programme with another Faculty within NUS

Students interested in pursuing a double degree with another faculty within NUS can do so by discussing their plans with their academic advisors, as well as the School of Computing's Office of Undergraduate Programmes. Such a self-designed programme provides maximal flexibility for students to pursue multidisciplinary education that fits their goals of education.

Some of the self-planned popular double degree programmes are joint with Mathematics, Quantitative Finance, Business and Geography, to name a few.

Students will apply for the double degree programme by submitting their applications to the Vice-Dean (Undergraduate Programmes), School of Computing Undergraduate Office, after completing between 60 and 80 MCs. They must obtain the approval of the Faculty in which they are seeking to do the second degree, and ensure that they have met the minimum CAP requirement of 4.00 for consideration and acceptance into the second degree programme.

A student may decide to withdraw or can be asked to withdraw from the double degree programme by withdrawing from the second degree. However, he/she is not allowed to withdraw from the first degree (i.e., the originally offered degree) programme and transfer to the second degree programme. All modules which the student has taken to fulfil the requirements of the second degree will be reflected in the transcript and included in the computation of the CAP.

For Students admitted with effect from AY 2011/12 onwards:
Students who have not achieved a CAP of 4.00 in modules contributing to the original degree, and a CAP of 3.50 for the degree for any two consecutive semesters will be required to withdraw from the double degree programme by withdrawing from the second degree programme.

The NUS double degree framework is given at :
 http://www.nus.edu.sg/registrar/edu/UG/spugp-double-degree-guidelines.html

(A) University Level Requirements

tudents are required to complete 20 MCs for this requirement. Students will be required to read one General Education Module (GEM) from each of the five pillars to satisfy the University Level Requirements for General Education. Please refer to the GEM website at http://www.nus.edu.sg/registrar/gem for the details.

(B) Faculty Requirements

A student reading for a double degree within the same Faculty will only need to fulfil one set of faculty requirements. If the two degrees are from two Faculties, both sets of faculty requirements will have to be fulfilled.

(C) Major Requirements

At least two thirds of each major must be fulfilled by distinct (i.e., not overlapping) modules. A minimum 60% of major credits of each of the degrees must be letter graded and factored in the CAP of each degree.

(D) Unrestricted Electives

Students will not be required to take Unrestricted Elective (UE) Modules. However, if UE modules are taken, these can be used to count towards the requirement of either degree programme. Modules double counted towards the major requirements of both degrees may not be double counted towards a Minor as well.

(E) Maximum Period of Candidature

The maximum period of candidature will be six years. The two degree programmes must be undertaken and completed within a single continuous candidature period (save for the usual provisions for leave of absence).

(F) Computation of CAP

- The CAP for both degree programmes will be computed separately and the two CAPs, one each for the respective degree programme will be reflected separately on the transcript.
- Students are required to classify their modules every semester by declaring which modules they want to use to fulfil the requirements of each of the two degrees.
- The grades from modules (Singapore Studies, GEMs, faculty requirements or majors) that may be double counted will be used twice to compute the CAP for each of the two degrees.
- If Unrestricted Elective (UE) modules have been taken, the grades obtained will be used to compute the CAP for either one of the two degrees.

(G) Minimum MC Requirements for Double Degrees

The minimum MC requirements for double degrees are as follows:
Double Honours Degrees – 200 MCs
Double Honours and Bachelor Degrees – 180 MCs

The actual total MCs will be dependent on the requirements of each of the two degrees and how much double counting is permitted as specified by the respective Faculties/Departments.

(H) Award of Degree

Two separate degrees will be awarded and two degree scrolls issued, one for each degree.

3.3.2 Double Degree Programme in Computer Science/ Information Systems and Business Administration/ Business Administration (Accountancy) (Honours/non-Honours)

Please refer to http://www.nus.edu.sg/registrar/nusbulletin/Otherprogs/ddp.html#5_4.

3.3.3 Double Degree Programme in Computer Science and Mathematics/Applied Mathematics (Honours/non-Honours)

Please refer to http://www.nus.edu.sg/registrar/nusbulletin/Otherprogs/ddp.html#5_5.

3.3.4 Double Degree Programme with French Grandes Écoles

The School offers Double Degree programmes with French Grandes Écoles, École Polytechnique (X), École Centrale Paris (ECP), École Supérieure d'Electricité (Supélec), École Nationale des Ponts et Chaussées (ENPC), École Nationale des Mines de Paris (ENSMP), TELECOM ParisTech (École Nationale Supérieure des Télécommunications) and ENSTA ParisTech (École Nationale Supérieure de Techniques Avancées) , seven premiere French institutions. The Double Degree Programme (DDP) with French Grandes Écoles provides the opportunities to learn from the best of both worlds, exposure to foreign cultures, networking with Singaporeans and foreigners, and proficiency in a third language.

Outstanding candidates for the double degree programme are selected in their first year. The successful candidates will undergo language preparation, spend their third and fourth year in the French institution, and return to NUS for their fifth (final) year. Students will graduate with a Diplôme d'Ingénieur from the French Grande École and a M.Sc. or M.Comp. from NUS.

For more details, please see: http://www.fddp.nus.edu.sg/.

3.3.5 Double Major Programmes

A second major will consist of at least 48 MCs of modules of which:

1. Only 8 MCs can be double counted.
2. At least 16 MCs must be at Level-3000 or above.

The requirements of a Double Major are as follows:

(A) University Level Requirements

Students are required to complete 20 MCs for this requirement.

(B) Faculty Requirements

Students need to fulfil the faculty requirements of the primary major.

(C) Major Requirements

Students are required to completely fulfil all the requirements of the primary major and the second major. Up to 8 MCs of the modules in the second major can be used to double count towards either the Faculty, Primary Major or Minor requirements.

Students may not need to take Unrestricted Elective (UE) Modules if the ULR and two majors add up to 160MCs or more. USP students must satisfy the prevailing USP requirements. The Advanced Modules can only be drawn from the primary major. The prevailing rules/policy concerning the S/U will apply for Double Major students.

(D) Computation of Cumulative Average Points (CAP)

Since students are graduating with only one degree, there will be a common CAP for both majors.

(E) Minimum MCs Requirements for Double Majors

The minimum MCs requirements for the Double Majors are as follows:

Single Degree, Double Major Programmes	Minimum MC requirement
With Honours	160
Without Honours	120

If the above minimum requirements are achieved, it would be possible to complete a Double Major with Honours in one subject within four years. The actual total MCs will

depend upon the requirements of the second major.

(F) Residency Requirement

The residency requirement is 50% of the minimum required MCs for the Double Major programme or 80 MCs, whichever is the higher.

(G) Maximum Period of Candidature

The maximum period of candidature for a Double Major is the same as that for a single major under the same degree.

(H) Awards

A Double Major student will only be eligible for award of medals and prizes associated with the primary major unless the medal/prize is to be awarded for best performance in a module. The second major will only be mentioned in the transcript and not on the degree scroll.

3.3.5.1   Double Major in either Management or Management (Technology)

SoC students interested in doing a double major programme from the School of Business may refer to section B3 of Part II of this bulletin for double major in either Management or Management (Technology). Details on these two double major programmes are available at: http://bba.nus.edu/major.htm and http://bba.nus.edu/tech.htm respectively. Students are required to apply for the second major and each application will be reviewed on a case-by-case basis.

3.3.5.2   Double Majors in the Faculty of Arts and Social Sciences

SoC students can refer to:
http://www.fas.nus.edu.sg/undergrad/toknow/academic_requirements/double_majors.html for details.

3.3.5.3   Double Majors in the Faculty of Science

SoC students can refer to:
http://www.science.nus.edu.sg/undergraduates/curriculum/majors/ for details.

3.3.6   Minor Pogrammes

A Minor programme is a coherent course of study. It provides significant depth, but unlike a specialisation, it does so in an additional area outside of the Major. By doing this, it

contributes to the breadth of learning envisaged for undergraduate education.

The modular credit (MC) requirement for a Minor programme should be at least 24 MCs. Up to 8MCs (out of 24MCs) may be used to meet the requirements for both the Minor and a Major or another Minor, subject to the agreement of the particular department(s), faculty/faculties or programme(s) hosting the Minor.

At least 12 MCs (out of 24 MCs) for any Minor programme must be taken from outside the entire set of modules that are listed for the major(s)/another minor that the student is taking/has taken.

The MCs under Unrestricted Elective module requirements can be used to satisfy the Minor programme requirements.

For students matriculated in AY2014-15 and after: A minimum 16 MCs of the Minor requirements must be earned from modules read in NUS, unless indicated otherwise by Faculties/Departments for specific minors. Modules read at NUS include all modules taught, co-taught, supervised or co-supervised by one or more NUS faculty members. These would consist of graded modules with assigned grade points, or modules with an 'S' or 'CS' grade. The other 8 MCs may be earned through credit transfers, advanced placement and exemptions, provided these MCs are earned from modules deemed relevant to the particular Minor programme.

The Minor programme(s) will be reflected in the student's transcript. Computing students are free to read any minor, subject to availability. Examples include Mathematics, Optical and Semiconductor Technology, and Technopreneurship minors.

The Minor programme(s) will be reflected in the student's transcript.

The following two minors are offered to students outside the School of Computing:

- Computer Science
- Information Systems

3.3.6.1   Minor in Computer Science

Objective

This minor will provide students from non-computing disciplines a competent level of programming skill, as well as basic knowledge in the fundamental fields of computing.

Structure

To be awarded a minor in Computer Science, students must pass six modules from the three categories below, with a total of at least 24 MCs.

Category I:
Complete the following two modules:

CODE	TITLE	MCS
CS1010	Programming Methodology	4
CS1020	Data Structures and Algorithms I	4

Students may take the equivalents to CS1010 and CS1020. For examples, CS1010E,CS1010FC,CS1010J, CS1010S,CS1101S, and CS1020E

Category II:
Complete three modules from the following list:

CODE	TITLE	MCS
CS2010	Data Structures and Algorithms II	4
CS2100	Computer Organisation	4
CS2102	Database Systems	4
CS2103	Software Engineering	4
CS2104	Programming Language Concepts	4
CS2105	Introduction to Computer Networks	4
CS2106	Introduction to Operating Systems	4
CS2107	Introduction to Information Security	4
CS2108	Introduction to Media Computing	4

Category III:
Satisfy the total MCs requirement (of 24) by taking one CS module with the following module codes:
CS321x, CS322x, CS323x, CS324x

Students may read advanced modules upon approval from the Department of Computer

Science, in place of modules listed in the programme B.Eng. (Computer Engineering). Students from the Faculty of Engineering and Computational Science from the Faculty of Science are precluded from reading this minor.

3.3.6.2   Minor in Information Systems

Objective

Information Technology (IT) has become a key component of organisations today. Its impact is felt from the way organisations are structured all the way to the design, development, manufacture and marketing of products. It enables organisational and operational processes. It is also embedded in products and services. It is vital that this key resource is efficiently managed.

The aim of this minor is to introduce students to the key concepts involved in the management of IT. The target audience for this minor consists of both users of technology as well as providers of technology. The course should benefit would-be managers, engineers and entrepreneurs.

Structure

To be awarded a minor in Information Systems, a student must pass a total of six modules, with a total of at least 24 MCs. The student must pass these three modules:

Set A

CODE	TITLE	MCS
IT1001$^+$	Introduction to Computing	4
IS1103	Computing and Society	4
IS1105	Strategic IT Applications	4

or

Set B

CODE	TITLE	MCS
CS1010/E/FC/S	Programming Methodology	4
CS1020/E	Data Structures and Algorithms I	4
IS1105	Strategic IT Applications	4

and any three modules from the following list

CODE	TITLE	MCS
IT2001*	Network Technology and Management	4
IS3101	Management of Information Systems	4
IS3150	Digital and New Media Marketing	4
IS3221	Enterprise Resource Planning Systems	4
IS3222	IT and Customer Relationship Management	4
IS3230	Principles of Information Security	4
IS3240	Economics of E-Business	4
IS3241	Enterprise Social Systems	4
IS3243	Technology Strategy and Management	4

+ GEK1511 can be used to replace IT1001 to fulfil the minor requirements.
* Engineering students (Course codes: EEE%, CPE% and ENG1) are precluded from reading IT2001.

Note:
Some of these modules require prerequisites from outside this list. Students must have the prerequisites to take them.

3.4 Enrichment Programmes

3.4.1 Advanced Technology Attachment Programme

The Advanced Technology Attachment Programme (ATAP) is a premium industrial attachment programme placing the better among our students in reputable and established organisations for the benefit of both. The objective of the six-month attachment programme is to enable students to apply their computing knowledge in computing-related projects through attachments at organisations.

ATAP aims to broaden students' education by enabling them to appreciate the application of computing knowledge to industry-related projects. Students' progress on projects will be monitored during attachment, and their performance will be assessed at the end of the attachment, based on the interim and final project reports. Students will be given 12 MCs with Completed Satisfactory (CS) grade upon successful completion of the programme.

For more details, please refer to: http://www.comp.nus. edu.sg/undergraduates/beyond_atap.html.

3.4.2 Industry Internship Programme

The Industry Internship Programme (IIP) enables students to apply the computing knowledge and skills that they have acquired in class to industry internships in companies/organizations. Students, work in pairs, in industry internships will be jointly guided by supervisors from both the companies/organizations and the school. Their progress on internship projects will be monitored during internship period, and their performance will be assessed through letter grades at the end of the internship. The internship duration will be 6 months, consisting of both a full-time and part-time component. Full-time internship attachment will last for 3 months during the NUS vacation period, and will continue on a part-time basis that will last for 3 months during the NUS study semester. Students will be given 12 MCs upon successful completion of the programme.

More details can be found at: http://www.comp.nus.edu.sg/undergraduates/

3.4.3   Student Internship Programme

This internship programme is similar to ATAP in objective and quality, but unfolds in three rather than six months. It places students in established organisations, both local and overseas, so that they may work on industry related projects from government agencies and multinationals in sectors ranging from financial services to interactive digital media and bioinformatics research during their special terms which span from May to July annually. Students will receive 6 credits with Completed Satisfactory (CS) grade under CP3200 on successful completion of the internship.

More details can be found at: http://www.comp.nus.edu.sg/undergraduates/

3.4.4   Undergraduate Research Opportunity Programme

The School of Computing offers the Undergraduate Research Opportunity Programme (UROP) in Computing to provide opportunities for research in computing by talented undergraduate students.

The aim of this programme is to foster intellectual exchange and collaboration between undergraduates and academic staff members. It allows undergraduates to participate in active research at the School of Computing, and to experience first-hand the challenges and exhilaration of research, discovery and invention. Students will be working at the frontiers of computing research and this exposure will complement their coursework.

Students will conduct research under the supervision of faculty members of the School of Computing. Typically, the research involves the following activities: problem formulation, literature survey, attending research seminars, proposal and implementation of solution, evaluation, and documentation and presentation of results. The relative importance of each of the above research activities can vary widely, depending on the chosen research topic (ranging from basic research to applied research to innovative application development).

Two modules are offered under the UROP (Computing) programme:

Code	Title	MCs	Prerequisites
CP3208	Undergraduate Research in Computing I	4	Pass 60 MCs and with approval from respective department.
CP3209	Undergraduate Research in Computing II	4	CP3208

A student participating in UROP (Computing) takes a two module (8 MCs) sequence spread over two semesters – CP3208 in the first semester, followed by CP3209 in the second semester. Even though each UROP (Computing) module is a one semester module, it is understood that this will also include compulsory full-time research work during the vacation preceding the semester.

It is expected that the student will complete an initial research study on the project in CP3208 (vacation and first semester) and complete the research project in CP3209 (the following vacation and second semester).

Eligibility and Workload

To be eligible for UROP (Computing), a student must have

1. Completed the prerequisites of CP3208, and
2. A minimum CAP of 3.80 (out of 5).

A student who applies for UROP (Computing) is committed to take the two module (8 MCs) sequence of CP3208 and CP3209. CP3208 and CP3209 must be completed before (and not concurrently with) CP4101 (B. Comp. Dissertation). Therefore, a student should plan to finish the CP3208-CP3209 sequence before starting CP4101.

A student can take only one UROP (Computing) module per semester. CP3208 or CP3209 will contribute 4 MCs each to the semester workload.

Administration

The programme is administered by the Office of Special Programmes in the School of Computing. Application for UROP (Computing) is open for either semester. Eligible students can get the application forms from the Office of Special Programmes. More details can be found at: http://www.comp.nus.edu.sg/undergraduates/beyond_urop.html

3.4.5   University Scholars Programme

The University Scholars Programme (USP) is a bold initiative to develop the personal, intellectual and leadership abilities of promising men and women enrolled at the National University of Singapore. It aims to foster active learners who can:

- Think and write critically, clearly and effectively;
- Synergise existing ideas, and create new ones;
- Make path-breaking connections within a discipline and among diverse disciplines; and
- Reflect deeply on themselves and their place in society.

The School of Computing is one of the participating faculties in the University Scholars Programme. Computing students who are admitted to the USP are called University Scholars. They can choose to read any one of these four-year honours programmes in the School:

- Bachelor of Engineering in Computer Engineering
- Bachelor of Computing in Computer Science
- Bachelor of Computing in Information Security and

- Bachelor of Computing in Information Systems.

Scholars will also have the unique privilege of declaring his or her final choice of faculty after three to four semesters (provided the criteria are met).

For details on the general University Scholars Programme requirements, please see the Scholars Programme website at: http://usp.nus.edu.sg

Specific requirements for Computing degrees

Students in the University Scholars Programme (USP) who opt for the School of Computing can choose any of the four-year programmes from the School. For each of these programmes, USP students will have to meet the same degree requirements as other SoC students but with the following variations:

All USP students will be taking the following under the Scholars Programme:

The three-tier structure will be as follows:

1. Foundations: 3 modules at 12 MCs

Three modules, all compulsory, are:

- Writing and Critical Thinking
- Quantitative Reasoning Foundation
- University Scholars Seminar

The modules will be offered at level-2000.

2. Inquiry: 8 modules at 32 MCs

Eight modules are divided equally between Humanities and Social Sciences and Sciences and Technologies baskets. Every USP student will take four modules from each basket. Students take at least one and up to three ISMs in place of regular inquiry modules. Each ISM will be counted as equivalent to one inquiry module in the appropriate basket. Modules will be offered at both levels 2000 and 3000, and will include current first-tier modules, and some current USP-based advanced modules.

3. Reflection: 1 module at 4 MCs

A single module, the Senior Seminar, designed to bring students together towards the end of their degree in order to reflect on disciplinary knowledge.

Module Substitutions
Students taking single degrees will be able to substitute a maximum of four inquiry modules. SEP students will be able to substitute two inquiry modules per semester of overseas study.

Please refer to the USP website at: http://usp.nus.edu.sg for more details.

3.4.6   NUS Overseas Colleges Programme

The NUS Overseas Colleges programme is an internship programme with strong

emphasis on technology entrepreneurship. The focus is on internship in a high-technology start-up located in an entrepreneurial and academic hub. Selected candidates will spend 12 months with a high-technology start-up and be required to take entrepreneurship courses at a designated partner university.

This programme incorporates a Bachelor (Honours) (with technopreneurship minor) degree. NUS students who participate in any 12-month NOC programme can obtain up to 48 MCs maximum. The composition will be:

- 12 MCs (maximum) for entrepreneurship courses;
- 8 MCs for discipline based courses; and
- 28 MCs for internship work, which could be considered for suitable mappings towards programme requirements by the student's home faculty.

For more information on this programme, please refer to: http://www.nus.edu.sg/noc/

3.4.7   Student Exchange Programme

The NUS Student Exchange Programme (SEP) provides students with the opportunity to study in an overseas partner university, usually for a semester or two, with approval of the School, to further enhance their learning experience. Students from either partner university pay fees only at their home institution while on exchange. The new experience provided by SEP is a once-in-a-lifetime opportunity that will enrich the life of the student forever.

Some of the partner universities include Uppsala University, McMaster University, University of Texas Austin, University of British Columbia, McGill University, University of California, University of Melbourne, Carnegie Mellon University and University of Illinois, Urbana Champaign.

Please visit:
http://www.comp.nus.edu.sg/undergraduates/beyond_sep.html for details.

3.4.8   Incubation Project

Students who wish to experience the entrepreneurship spirit that permeates the School are welcome to bring their idea, put it into a business plan, and bring it into fruition. The School Incubation Centre provides support to students for their ideas to be germinated into a money-making business. Students could also earn credits towards their degree requirement through registering for CP3109 Incubation Project module. In this module, students will submit their reports to the Incubation Centre Review Committee. The committee will assess students' ability in managing and operating their companies.

Besides the various technopreneurship modules offered by NUS, the School also offers a module on digital entrepreneurship that cover trends in the digital marketplace and emerging high-growth opportunities for digital businesses. The module will highlight issues facing companies with new products and services in an ever-changing digital marketplace. It also focuses on opportunity identification and sources of competitive differentiation, particularly as they relate to digital innovation.

3.5   Financial Assistance and Awards

3.5.1   Faculty-administered Scholarships

The School administers the following scholarships:

- Computing Scholarship
- Kwan Im Thong Hood Cho Computing Scholarship
- Lim Hong Chin Memorial

Details can be found at: http://www.comp.nus.edu.sg/undergraduates/

3.5.2   Faculty-administered Awards/Funds

The School administers the following three Awards/Funds:

i. **Computing Alumni Assistance Award**

The Award will subsidise undergraduates special educational expenses and/or other financial requirements of self-contained educational programmes as determined by the Selection Panel for a one-off assistance up to a maximum value of THREE THOUSAND dollars (S$3,000.00) per award.

More details can be found at:
http://www.comp.nus.edu.sg/undergraduates/support_computing_alumni.html

ii. **Computing Bursary**

The Bursary, established from the School's pooled endowed fund, will serve as additional top-up to needy SoC students to cover their tuition fees. Needy students should apply to the Office of Financial Aid before they can be considered for this bursary. The School will provide appropriate amount to students per academic year subject to the availability of funds and student's per capital income (PCI).

iii. **Computing Student Development Fund**

The Fund will subsidise students' overseas study trips and certification course such as those by SAP, IBM, Oracle and Sun and to send graduate students to participate in top academic conferences as determined by the Selection Panel for a one-off assistance up to a maximum value of ONE THOUSAND AND FIVE HUNDRED dollars (S$1,500.00) per student per academic year.

More details can be found at:
 http://www.comp.nus.edu.sg/undergraduates/support_computing_stud_dev_fund.html

3.5.3   Faculty-administered Prizes

Medals and book prizes are awarded to top students at the various stages of study, in recognition of their outstanding academic performance, in addition to the Dean's List. The following are faculty-administered prizes for undergraduates:

Book Prizes	Basis
Microsoft Prize	Best undergraduate student throughout the course of study in either Computing or Computer Engineering course
Tata Consultancy Services Asia Pacific Prizes	Best second- and third-year students throughout the course of study in either Computing or Computer Engineering course

4   Graduate Education

The Graduate Studies' Office offers comprehensive postgraduate programmes through advanced and in-depth course curriculum, which develops and enhances the candidate's knowledge, and prepares them to address the complex IT issues at their workplaces.

4.1   Research Programmes

The School welcomes graduates with good academic potential and strong interest in research to be a part of the Graduate Programme. A premier research-based programme leading to a doctoral degree, it is available in both the Department of Computer Science and Department of Information Systems.

4.1.1   Degrees Offered

The School of Computing offers the following research degree programmes:

- Doctor of Philosophy (Ph.D.)
- Master of Science (M.Sc.), if the candidate fails the Qualifying Examination but is allowed to complete as a M.Sc. candidate

4.1.2   Degree Requirements

Structure of Programme (Computer Science)		
Year 1	Semester 1	2 graduate modules + CS6101 (Exploration of CS Research)
	Semester 2	2 graduate modules + Research

Structure of Programme (Computer Science)		
Year 2	Semester 1	2 graduate modules + QE
	Semester 2	Research
Year 3	Semester 1	Research + Thesis Proposal + Doctoral Seminar
	Semester 2	Research
Year 4	Semester 1	Research
	Semester 2	Ph.D. Defence (Seminar Presentation + Oral Defence)

CS Ph.D. candidates who are required to complete six graduate modules (24 modular credits) will need to take at least one module each in any three of the five clusters – Algorithm and Theory, Computer Systems, Knowledge Systems, Media Technologies or Programming Language and Software Engineering. Out of the six graduate modules, at least two (8 modular credits) must be at level 6000, and at least another three modules must be at level 5000 (or above). These modules may belong to the five clusters or may be offered by other departments. CS Ph.D. students are allowed to take at most one level 4000 module. Students should complete all coursework requirements by the end of third semester.

Ph.D. students admitted to the Department of Information Systems (IS) will follow the structure for the IS Ph.D. programme:

Structure of Programme (Information Systems)		
Year 1	Semester 1	2 Core Modules + Research
	Semester 2	3 Core Modules + Research
Year 2	Semester 1	Ph.D QE Module (QE I) + 2 Track Modules + GRP (QE II)
	Semester 2	2 Track Modules + Research

Structure of Programme (Information Systems)		
Year 3	Semester 1	Research + Teaching
	Semester 2	Research + Thesis Proposal + Teaching
Year 4	Semester 1	Research + Teaching
	Semester 2	Teaching + Ph.D. Defence (Seminar Presentation + Oral Defence)

All IS Ph.D. candidates are required to complete five common core modules, spanning the different streams of IS research. This is compulsory for all students to increase their breadth of knowledge. The five modules consist of three modules that cover research methods, one module that covers theories, and one module for a seminar on recent topics in all three IS research tracks (behavioral, technical, and economics).

Upon completion of the common core modules, IS Ph.D students would be directed to a more structured set of modules in one of the three different tracks that they can choose from. Based on their choice of track, they will follow a logically structured curriculum of two track core and two electives modules that ensures breadth and depth of knowledge in their area.

All Ph.D. candidates are required to achieve a minimum CAP of 3.5 (B grade) for the modules taken.

All PhD candidates must pass their Qualifying Examination I (QE I) within 18 months after admission. A maximum of two attempts will be allowed.

The Ph.D. Qualifying Examination for IS Ph.D. students consists of the Ph.D. QE I (PhD QE module IS6000) and Ph.D. QE II (Graduate Research Paper (GRP)). The IS Qualifying Examination I (QE I) which will test the integration of concepts from the common core modules that all students would have taken.Students are to work on the Graduate Research Paper (GRP) with a faculty member immediately after the first semester's exam or soonest, and to participate in lab activities with the view of producing a quality research/survey paper by the third semester. The GRP presentation will be evaluated by a panel not later than the end of the third semester.

Ph.D. students taking the CS QE are evaluated based on a research-based paper which should contain critical review of research papers and demonstrates problem-solving abilities of the student, both assigned by the student's supervisor. The QE paper will be assigned according to one of the six research clusters for evaluation (Algorithms and Theory, Artificial Intelligence, Computer Systems, Database and Data Mining, Media or Programming Languages and Software Engineering). Students will be required to give a presentation to the panel.

All students' Thesis Advisory Committee (TAC) will be set up after passing the QE, and the student should present his/her research to the TAC. This is to ensure that the TAC is in touch with the student's research progress.

By end of Year 3, candidates are expected to complete their thesis proposal. The thesis proposal should highlight the significance of the research topic, its goal, the approach adopted, and work to be done. It should be precise and convincing to the examiners that the

candidate is proposing a novel area of research and the goal is achievable. The thesis proposal comprises of an open seminar presentation (doctoral seminar), followed by a close-door oral examination. Those who pass the thesis proposal will proceed to the final phase of research. Ph.D. students are normally expected to finish their Ph.D. candidature within four years by passing the thesis examination and oral defence

Duration of Programme

The following maximum candidature periods are inclusive of periods of approved study leave:

- Masters: 36 months
- Ph.D.: 60 months

4.1.3 Financial Assistance and Awards

President's Graduate Fellowship (PGF)

The PGF is awarded to candidates who show exceptional promise or accomplishment in research. A small number of PhD research candidates are selected each semester by the University for the Fellowship. Selected candidates will receive a monthly allowance of S$3,300 (for Singapore citizens) and S$3,000 (international students). The award is tenable for an initial one year and, subject to an annual review of the scholar's research progress, it can be renewable up to a maximum of 4 years.

NUS Research Scholarship

Financial Assistance in the form of the NUS Research Scholarship is available, on a competitive basis to all full-time students who meet the criteria. The Research Scholarship will carry monthly emoluments, plus full tuition fee subsidy. Candidates with good undergraduate degrees in computer science or information systems are invited to apply for research scholarships. These are for pursuing full-time Ph.D. programme in the School. They are tenable for one year in the first instance and renewable annually for up to four years for Ph.D. candidates, subject to satisfactory performance. Research scholars who passed their Ph.D. Qualifying Examination will be awarded an additional top up of S$500 per month during their Ph.D. candidature.

SAP Industry PhD Scholar Programme

SAP Asia, in partnership with the National Research Foundation and NUS, is offering the SAP PhD Scholar Programme to outstanding individuals who are keen to pursue a higher academic calling, while working at the forefront of technology in a world leading company.

All candidates must meet the admission requirements of the University's PhD programme and go through all necessary academic milestones.

Teaching or Research Assistantships

Research scholars who have fulfilled their Graduate Assistantship Programme requirements may apply for teaching assistantships with the Departments. Such assistantships will require them to assist in departmental work such as conducting tutorials/laboratory demonstrations, preparation of teaching materials, invigilating at examinations etc.

Full-time graduate students may also apply for part-time research assistantships to assist the

Principal Investigators (PI) with specific research duties.

All appointments are subject to the terms and conditions stipulated under such appointments. International students are also required to abide by the Immigration & Checkpoints Authority (ICA) guidelines.

Graduate Awards

The following graduate awards are given to encourage and recognise continuous and sustained research excellence in graduate research students:

I. **Research Achievement Award**

This award will be given to outstanding Ph.D. students each academic year, encouraging students to strive towards continuous research achievement during their Ph.D. candidature.

Award Criteria:

The recipients of this award will each receive a certificate and $250 cash prize.

A. Be either a full-time or part-time Ph.D. student throughout the whole semester at the time of award presentation.

B. Achieved outstanding performance (over a one-year period) in terms of:

   i. Publications in Rank-1 journals/conferences
   ii. Registration for patent
   iii. Significant system development of either commercial interest or wide usage by organisations not related to the development work
C. In all cases, the student must be a significant contributor/primary author of the achievement.
D. Awards will be given out twice a year.
The recipients of this award will each receive a certificate and $250 cash prize.

II. **Dean's Graduate Research Excellence Award**

The Dean's Graduate Award is a prestigious award to be given to senior Ph.D. students who have made significant research achievements during their Ph.D. study, and the award criteria are:

- Deserving recipients to be given this award once throughout their candidature;
- Nomination to be made by supervisors;
- Award only given once per academic year;
Winners will each receive a certificate and $1,000 cash prize.

The judging criteria for Dean's Graduate Awards will be the same as the Research Achievement Award. In addition, nominees must produce strong evidence of sustained research achievements during their course of study.

Students who have been awarded one of the awards will not be able to receive the other simultaneously.

4.2   Coursework Programmes

4.2.1   Master of Computing

The Master of Computing programme (M.Comp.) offered by the School of Computing, is a comprehensive and challenging graduate programme with area specialisations. It encompasses latest research findings, both applied and fundamental. The programme also provides advanced and in-depth knowledge of IT to prepare the students for challenges in IT career.

Structure of Programme

Candidates admitted to the MComp programme, can apply to one of the following specialisations offered in the School:

- Computer Science; or
- Infocomm Security; or
- Information Systems

Computer Science (CS) and Information Systems (IS) Specialisations

Students are required to pass ten modules, with at least five modules selected from their specialisation (total of 40 modular credits).

The remaining five non-specialisation modules can be chosen from level 5000 to 6000 modules offered by the School of Computing.

Students are allowed a maximum of two level 4000 modules and two modules (must be at least level 5000) from other faculties.

Dissertation Option

Students in CS or IS specialisations will be allowed the flexibility of taking the dissertation option which is equivalent to four graduate level modules (16 modular credits). Students will need to complete six graduate level modules, with at least three modules from the area of specialisation (24 modular credits).

The dissertation option gives individual students the opportunity for independent study and research in the area of their selected specialisation. This will be carried out under the supervision of an academic staff, and the selection of the topic/area will be done in consultation with the supervisor in the area of expertise.

Infocomm Security (InfoSec) Specialisation

Students enrolled to the Infocomm Security specialisation from August 2015 intake onwards will complete the MComp programme by selecting one of the following structures:

Option 1

InfoSec specialisation students under this option are to complete six graduate level modules, with at least four modules from the InfoSec specialisation (24 modular credits). A maximum of one level 4000 module is allowed.

In addition, they will need to complete a project which culminates with a dissertation (16 modular credits).

Option 2

Students will need to complete eight graduate level modules, with at least four modules from the InfoSec specialisation (32 modular credits). A maximum of two level 4000 modules is allowed.

Students will also complete a one-semester long project (8 modular credits). Students can

undertake an external company/agency-proposed InfoSec projects with a SoC faculty member's involvement, or a project proposed solely by an SoC faculty member.

Students are allowed a maximum of two modules (at least level 5000 and above) from other faculties.

The details of the pool of modules available are listed in Annex A in our website:

http://www.comp.nus.edu.sg/graduates/m_structure.html

Duration of Programme

Part-time and full-time candidates taking M.Comp. programme must complete the coursework requirements within the period as shown:

	Part-Time	Full-Time
Minimum Candidature	2 years	1 year
Maximum Candidature	3 years	3 years

Workload

The maximum and minimum workload for part-time candidates are 12 and 4 modular credits respectively, while the maximum and minimum workload for full-time candidates are 20 and 12 modular credits respectively.

Graduation Requirements

Candidates must achieve a final CAP of 3.0 (average grade of B-) to graduate, otherwise their candidature will be terminated.

Financial Assistance and Awards

Loans

All students who are enrolled in full-time coursework programme can request for loans up to 90 percent of their fees. For more information, please refer to: http://www.nus.edu.sg/registrar/edu/gd-fees.html

Awards

In recognition of the excellent performance of the graduate coursework students, the Microsoft Prize will be awarded to the Master of Computing student with the best cumulative average point (CAP) throughout the course of study.

4.2.2   Master of Science in Business Analytics

Please refer to Section R of Part II of this bulletin for details.