PREFACE

Information and Communication Technology (ICT) is an enormously vibrant field that emerged at the end of the last century as our society experienced a fundamental change from an Industrial Society to Information or a Knowledge-Based Society. ICT has emerged as a convergence of Computer and Communications Technologies.

This Document covers the **Computer-specific part** of ICT referred to as **Computing**.

Generally, Computing includes designing and building hardware and software systems for a wide range of purposes; processing, structuring, and managing various kinds of information; carrying out scientific studies using computers; making Computer Systems behave intelligently; creating and using communications and entertainment media; finding and gathering information relevant to any particular purpose, and so on.

From its inception just half a century ago, Computing has become the defining technology of our age, changing how we live and work. Computing has dramatically influenced progress in science, engineering, business, and many other areas of human endeavour. Computers are integral to modern culture and a primary engine of growth behind much of the world's economic and social change. It is considered the Primary Enabler to the Knowledge Based Economy or K-Economy.

The field continues to evolve at an astonishing pace. New technologies are introduced continually, and existing ones become obsolete almost as soon as they appear. The rapid evolution of the Discipline has a profound effect on Computing education affecting both content and pedagogy. Computing will continue to present challenging career opportunities, and those who work in computing will have a crucial role in shaping the future. To ensure Malaysia remains competitive and be propelled towards a fully-developed nation, **it is important that the Computing Disciplines attract quality students** from a broad cross-section of the population and prepares them to be capable and responsible professionals, scientists, and technologists.

This Standard has made reference to documents produced by the joint Task Force for Computing Curricula which is a cooperative project of The Association for Computing Machinery (ACM), The Association for Information Systems (AIS) and The Computer Society (IEEE-CS).

Academically, Computing consists of several fields namely Computer Science, Computer Engineering, Information Systems, Information Technology, Software Engineering, and many more. Although these fields are related, they are quite different from each other.

The purpose of this Document is to underline Curriculum Standards in four Computing Disciplines namely, **Computer Science (CS), Information Technology (IT), Software Engineering (SE) and Information Systems (IS)**. The Computer Engineering Discipline is not covered under this document despite the fact that it is a sub-discipline under Computing due to the overlapping area of authority with the engineering professional bodies in Malaysia.

This document also provides a general overview of the different kinds of programmes in computing that should be made available according to new Computing Curriculum standards. Academics, Industry, administrators, students, and parents can benefit from this document.

Several questions naturally arise. What are these different kinds of Computing Programmmes? How are they similar? How do they differ? How can I tell what their names really mean? Which kinds of Programmes should our college or university offer? These are all valid questions, but to anyone unfamiliar with the breadth of computing, the responses to these queries may be difficult to articulate. The Document may help to provide some answers.

This Document explains the characteristics of the various Programmes in Computing, how they should be assessed and delivered. It should also help one determine which of the Programmes are most suited to particular goals and circumstances. We hope that this Document can be beneficial to a broad and varied audience, especially for the computing community.

INTRODUCTION

Computing for the purposes of this Programme Standards involves the study of computers and their applications. Thus, Computing includes designing and building hardware and software systems for a wide range of purposes; processing, structuring, and managing various kinds of information; carrying out scientific studies using computers; making Computer Systems behave intelligently; creating and using communications and entertainment media; finding and gathering information relevant to any particular purpose.

In the Malaysian context, Computing is always referred to as Information Technology (IT) or Information and Communication Technology (ICT). IT encompasses many aspects of computing and technology and it covers many fields. When Computer and Communication technologies are combined, the result is Information and Communication Technology (ICT). ICT is widely used as a phrase to describe Computing and IT. As a result, Computing degrees are always referred to as ICT degrees. Higher Education Providers (HEPs) used a variety of nomenclatures such as Computer Science, Software Engineering, Networking, Multimedia and Artificial Intelligence, all of which fall under the term *Computing*.

For the purpose of Malaysian Higher Education sectors, computing will be broadly categorised into four (4) major disciplines namely Computer Science, Information Systems, Information Technology and Software Engineering. These follow the classification of the Association for Computing Machinery (ACM) and they are:

- Computer Science: Graduates of this Discipline, called *Computer Scientists,* should be prepared to work in a broad range of positions involving tasks from theoretical work to software development and can adapt to innovations in ICT;
- Information Systems: Graduates of this Discipline, call*ed Information Systems Specialists,* should be able to analyse information requirements and business processes and be able to specify and design systems that are aligned with Organisational goals;
- Information Technology: Graduates of thi*s Discipline, called Information Technology Professionals,* should be able to work effectively at planning, implementation, configuration and maintenance of an Organisation's computing infrastructure; and

- Software Engineering: Graduates of this Discipline, called *Software Engineers,* should be able to perform and manage activities at every stage of the life cycle of large-scale Software systems.

The four (4) Disciplines provide the basic platform for placement of computing programmes. Higher Education Providers are given the autonomy to determine the specific nomenclature for their awards and this is subject only to the existing National and International best practices.

Computer Science spans a wide range, from its theoretical and algorithmic foundations to cutting edge developments in Robotics, Computer Vision, Intelligent Systems, Bioinformatics, Forensic Computing and other exciting areas. It involves designing and implementing software, devising new ways to use computers and developing effective ways to solve computing problems.

Computer Science offers a comprehensive foundation that permits graduates to adapt to new technologies and ideas. Computer scientists extend theories and practice for implementation of computer systems which has grown to include aspects of web development, interface design, security issues, mobile computing, and involvement in devising new ways to use computers.

Information Systems integrate Information Technology solutions and business processes to meet the information needs of businesses and other enterprises, enabling them to achieve their objectives in effective, efficient ways. This Discipline's perspective on Information Technology emphasises Information, and views Technology as an instrument for generating, processing and distributing information.

Information Systems programmes prepare graduates to work with business support applications such as payroll, accounts, receivables and inventory management. Information Systems Specialists are expected to become familiar with computer applications related to these traditional business areas, especially database-management systems and spreadsheets, and other off-the-shelf software products.

Information Technology in the broadest sense refers to all aspects of computing. However, in academia, it often refers to meeting the technological needs of business, government,

healthcare, schools, and other kinds of organisations through the selection, creation, application, integration and administration of computing technologies.

IT graduates are trained to focus on the application, deployment, and configuration needs of organisations and people over a wide spectrum. IT Professionals have a special focus on satisfying organisational needs that arise from Computing Technology. They assume responsibility for selecting hardware and software appropriate for an Organisation, integrating these with organisational needs and its infrastructure, and installing, customising, and maintaining those applications for the computer users in the Organisation.

Software Engineering is the Discipline of developing and maintaining software systems that behave reliably and efficiently, is affordable to develop and maintain and built to customers' specifications. It has evolved in response to factors such as the growing impact of large scale software systems in a wide range of situations and the increased importance of software in safety-critical applications.

Software Engineering programmes produce graduates who can understand user requirements and develop software systems. Software Engineers are expected to develop systematic models and reliable techniques for producing high-quality software on time and within a budget.

As a whole, the ***Programme Standards for Computing*** describes the different levels of standards leading to the award of individual qualifications, namely Certificate (Malaysian Qualifications Framework MQF Level 3), Diploma (MQF Level 4), Bachelor's Degree (MQF Level 6), Master's Degree (MQF Level 7) and Doctoral Degree (MQF Level 8). It has not incorporated Advanced Diploma (MQF Level 5) as the expert focus group for the Programme Standards felt that the qualification best fits the needs and demands of the non-conventional student entry mode and should be given opportunity to develop in accordance to the demand for such a qualification in the future.

These standards are designed to encourage diversity of approach within a framework that is compatible with the national and global human resource requirements and the socio-economic needs. They cannot be seen as a syllabus and no form of prescription is intended in the amount of time devoted to each component or the order in which the material is presented. Higher Education Providers are expected to combine, teach and assess the subject matter creatively.

The Programme Standards provides an inventory of content; delivery and assessment of programmes, thus enabling identification of vital components of qualifications from Certificate to Doctoral awards.

As the statements within the Programme Standards should be viewed as benchmark statements, Higher Education Providers are encouraged to go beyond the basic minimum. This Document is also intended to be valuable to potential students, their parents and guardians, employers, professional and regulatory bodies, universities, colleges and schools. Assessors and Auditors are guided by these standards in arriving at their recommendation and conclusions.

The development and implementation of this Programme Standards is to ensure that the graduates meet the professional requirements and expectations in their respective fields. Higher Education Providers must take cognisance of the rapidly evolving subject matter and introduce effective and sustainable programme improvement. In doing so, the providers should also ensure that the graduates obtain the necessary skills to function effectively.

Recognition of Prior Learning (RPL) will be in accordance to the 'Code of Practice for Quality Assurance of the Open Entry Admission System' and open-entry policies. Qualifications supporting lifelong learning, Advanced Diploma, Graduate Certificate and Diploma, and Postgraduate Certificate and Diploma should reflect the achievement in part of the learning outcomes for the respective levels. For example, a Graduate Certificate is placed at Level 6 of the MQF (Bachelor). Therefore, the learning outcomes should in part fulfill the learning outcomes at Bachelor level.

All partnership or collaborative programmes should accommodate, as much as possible, the requirements of this Programme Standards. As the purpose of this Programme Standards is to provide guidelines in relation to the development and conduct of programmes in the identified fields, it is of paramount importance that this document be read with other quality assurance documents and policies by the Malaysian Qualifications Agency and related agencies. These include but are not limited to:

1. The Malaysian Qualifications Framework (MQF);
2. The Code of Practice for Programme Accreditation (COPPA);

3. The Code of Practice for Institutional Audit (COPIA); and
4. Relevant Guidelines to Good Practices (GGP).

PROGRAMME AIMS

"A Programme's stated aims reflect what it wants the learner to achieve. It is crucial for these aims to be expressed explicitly and be made known to learners and other stakeholders alike" (COPPA, 2008, pp.10).

CERTIFICATE

Computing programmes at Certificate level aim to provide computing graduates with a broad range of interpersonal skills and an in-depth understanding and knowledge within their field of study to responsibly take on appropriate jobs. The nomenclature for the Certificates, for example, Certificate in PC Maintenance and Certificate in Networking should reflect concentration areas of the Programme.

The Programme Aims for a Certificate are to train graduates who

i. possess basic knowledge and skills in computing,
ii. can utilise computing tools and techniques by applying knowledge and interpreting information to solve problems,
iii. can execute routine tasks and are proficient in the use of relevant tools in their area of training,
iv. can perform IT support services ,
v. have communication, team and interpersonal skills, and are aware of their social and ethical responsibilities, and
vi. possess skills for lifelong learning and career development.

DIPLOMA

Computing programmes at Diploma Level aim to provide graduates with the skills and a broad-based knowledge to responsibly take on appropriate jobs with moderate autonomy. The graduates should possess a combination of knowledge and skill to assist in an organisation's computing infrastructure and its users.

Generic Programme Aims for a Diploma are to prepare graduates who

i. possess relevant knowledge, skills and aptitude to meet job specifications,

ii. can utilise current computing tools and techniques by applying knowledge and interpreting information to solve problems,
iii. can execute and be responsible for routine tasks,
iv. have effective communication skills to convey information, problems and solutions,
v. have team and interpersonal skills, and are aware of their social and ethical responsibilities, and
vi. possess skills for lifelong learning and career development.

Subject to the concentration in a particular Diploma and its nomenclature, the **Specific Programme Aims for the four (4) disciplines** identified in this Programme Standards are:

A. Computer Science

The Programme should prepare graduates who

i. have knowledge of algorithms, software methods and current programming languages, and
ii. have the ability to analyse, design and develop computer applications.

B. Information Systems

The Programme should prepare graduates who

i. have knowledge of organisational and systems needs, and
ii. have the ability to configure, deploy systems and utilise software according to the organisational needs.

C. Information Technology

The Programme should prepare graduates who

i. have an understanding of the importance of human-computer-interaction, and
ii. have the ability to configure, integrate and deploy systems, and provide technical support within the organisations.

D. Software Engineering

The Programme should prepare graduates who

i. have knowledge of processes for the development of software projects,
ii. have the ability to assist in the development of systematic models, and

iii. have the skills to adhere to standard process-oriented methodologies and procedures for producing high-quality software on time and within a budget.

BACHELOR'S DEGREE

Computing programmes at Degree Level aim to provide graduates with sufficient knowledge and skills to take on appropriate responsibility with a higher degree of autonomy from the Diploma holders. The graduates should possess the ability to be responsible for an Organisation's computing infrastructure and its users.

Generic Programme Aims for a Bachelor's Degree are to prepare graduates who

i. possess skills for lifelong learning, research and career development,
ii. have communication, team, leadership and interpersonal skills, and aware of the social, ethical and legal responsibilities, and
iii. have entrepreneurial skill and a broad business and real world perspective.

Subject to the specialisation/major/minor in a particular Bachelor's Degree and its nomenclature, the **Specific Programme Aims for the four (4) disciplines** identified in this Programme Standards are:

A. Computer Science

The Programme should prepare graduates who

i. possess fundamental knowledge, principles and skills in Computer Science,
ii. have strong analytical and critical thinking skills to solve problems by applying knowledge, principles and skills in Computer Science, and
iii. possess theoretical computing knowledge in analysing, modelling, designing, developing and evaluating computing solutions.

B. Information Systems

The Programme should prepare graduates who

i. possess fundamental knowledge, principles and skills in Information Systems,
ii. have strong analytical and critical thinking skills to solve problems by applying knowledge, principles and skills in Information Systems, and

iii. understand business requirements and have the ability to plan, design and manage business Information Systems, with the relevant technology and knowledge to enhance organisational performance.

C. Information Technology

The Programme should prepare graduates who

i. possess fundamental knowledge, principles and skills in Information Technology,
ii. have strong analytical and critical thinking skills to solve problems by applying knowledge, principles and skills in Information Technology,
iii. possess the ability to design, implement and manage Information Technology solutions and resources, and recognise the impact of technology on individuals, organisations and society, and
iv. possess skills to integrate various technology solutions.

D. Software Engineering

The Programme should prepare graduates who

i. possess fundamental knowledge, principles and skills in Software Engineering,
ii. have strong analytical and critical thinking skills to solve problems by applying knowledge, principles and skills in Software Engineering, and
iii. are competent in applying appropriate methodologies, models and techniques that provide a basis for analysis, design, development, testing and implementation, evaluation, maintenance and documentation of a large scale Software system.

MASTER'S DEGREE

Computing programmes at Master's level aim to provide Master's Degree holders with advanced knowledge and skills to deal with an Organisation's computing needs. The programmes are aimed to cater for both computing and non-computing graduates. In applying the aims below, Institutions are required to adapt in accordance to the needs of the candidates.

The Programme is to:

i. provide graduates with advanced knowledge and skills in computing;

ii. equip graduates with advanced theoretical principles and scientific methods to create effective solutions to problems and to evaluate them;
iii. train graduates to work on a project in which they propose, design, build, test, analyse, and deliver a computing solution to meet appropriate computing standards and realistic constraints;
iv. instill graduates with skills to seek knowledge through lifelong learning;
v. equip graduates with the ability to supervise and carry out research under supervision;
vi. develop graduates' effective communication skills in both written and oral form; and
vii. inculcate graduates with professional and ethical responsibilities as well as understanding the possible social, economic, cultural, legal and environmental impact of their computing solutions in the global context.

DOCTORAL DEGREE

As a terminal Degree in Computing, a Doctoral Level qualification should provide graduates with the ability to develop and expand knowledge and application of computing, both in the organisation and society.

The Programme is to:

i. prepare competent practitioners/researchers with a firm grounding in computing who can foster research and development of new knowledge in specific areas;
ii. equip practitioners/researchers with in depth knowledge of computing and a focused understanding in the area of expertise;
iii. prepare practitioners/researchers who can apply skills and principles of lifelong learning in academic and career development;
iv. develop practitioners'/researchers' effective communication skills in both written and oral form;
v. equip practitioners/researchers with the ability to supervise and carry out independent research; and
vi. inculcate practitioners/researchers with professional and ethical responsibilities as well as understanding the possible social, economic, cultural, legal and environmental impact of their computing solutions in the global context.

LEARNING OUTCOMES

"The quality of programme is ultimately assessed by the ability of the learner to carry out their expected roles and responsibilities in society. This requires the programme to have a clear statement of the learning outcomes to be achieved by the learner" (COPPA, 2008, pp.11).

These learning outcomes should cumulatively reflect the eight domains of learning outcomes, which are significant for Malaysia (MQF, 2007, Para 15).

CERTIFICATE

At the end of the Programme, graduates should be able to:

i. demonstrate an understanding of basic knowledge and skills in their area of concentration;
ii. utilise computing tools and techniques to solve problems related to the area of concentration;
iii. perform a range of support tasks such as installation, configuration, basic maintenance and data entry;
iv. execute instructions as described in user and technical manuals;
v. apply skills and principles of lifelong learning in academic and career development;
vi. communicate effectively with peers, clients, superiors and society at large;
vii. demonstrate teamwork, interpersonal, and social skills; and
viii. demonstrate professionalism, social and ethical considerations in accordance with ethical and legal principles.

DIPLOMA

Generic Learning Outcomes

At the end of the Programme, graduates should be able to:

i. demonstrate the ability to articulate and document work-flow and processes during project development;
ii. apply skills and principles of lifelong learning in academic and career development;
iii. communicate effectively with peers, clients, superiors and society at large;
iv. demonstrate teamwork, interpersonal, entrepreneurial and social skills; and

v. demonstrate professionalism and social and ethical considerations in accordance with ethical and legal principles.

Subject to the concentration in a particular Diploma and its nomenclature, the **Specific Learning Outcomes for the four (4) disciplines** identified in this Programme Standards are:

A. Computer Science

At the end of the Programme, graduates should be able to:

i. write computer programmes using at least one Industry relevant to software development environment;
ii. investigate a problem, model and design a solution, implement and test projects to meet real world needs;
iii. select appropriate algorithms for software solutions;
iv. design and develop user-friendly interfaces for problems; and
v. use industry relevant methods and tools in the management of computer-based Systems.

B. Information Systems

At the end of the Programme, graduates should be able to:

i. model an organisation's functional areas and its information requirements;
ii. obtain and analyse user's requirements; and
iii. configure and deploy off-the-shelf software packages for real-world projects.

C. Information Technology

At the end of the Programme, graduates should be able to:

i. document user requirements for real-world projects;
ii. design and develop user-friendly IT solutions in relevant areas;
iii. design and manage computer networks; and
iv. provide technical support and maintenance for computer solutions.

D. Software Engineering

At the end of the Programme, graduates should be able to:

i. apply professional practices in the development of software solutions;
ii. analyse, design and implement user-friendly systems;

iii. participate as part of a team in the development of a software project;
iv. assist in documenting all aspects of the development lifecycle to appropriate industry standards; and
v. assist in stakeholders meeting during project development.

BACHELOR'S DEGREE

Generic Learning Outcomes

At the end of the Programme graduates should be able to:

i. apply skills and principles of lifelong learning in academic and career development;
ii. communicate effectively with peers, clients, superiors and society at large;
iii. demonstrate teamwork, leadership, interpersonal and social skills;
iv. utilise relevant techniques and demonstrate analytical and critical thinking skills in problem solving;
v. demonstrate professionalism and social and ethical considerations in accordance with ethical and legal principles; and
vi. apply broad business and real world perspectives daily and demonstrate entrepreneurial skills.

Subject to the specialisation/major/minor in a particular Bachelor's Degree and its nomenclature, the **Specific Learning Outcomes for the four (4) disciplines** identified in this Programme Standards are:

A. Computer Science

At the end of the Programme, graduates should be able to:

i. demonstrate knowledge and understanding of essential facts, concepts, principles, and theories relating to Computer Science;
ii. apply theoretical principles of Computer Science in relevant areas; and
iii. demonstrate theoretical computing knowledge in analysing, modelling, designing, developing and evaluating computing solutions.

B. Information Systems

At the end of the Programme, graduates should be able to:

i. demonstrate knowledge and understanding of essential facts, concepts, principles, and theories relating to Information Systems;
ii. apply theoretical principles of Information Systems in relevant areas; and
iii. demonstrate understanding of business requirement and be able to plan, design and manage business Information Systems, with the relevant technology and knowledge to enhance organisational performance.

C. Information Technology

At the end of the Programme, graduates should be able to:

i. demonstrate knowledge and understanding of essential facts, concepts, principles, and theories relating to Information Technology;
ii. apply theoretical principles of Information Technology in relevant areas;
iii. design, implement and manage Information Technology solutions and resources, and recognise the impact of technology on individuals, organisation and society; and
iv. integrate various technology solutions.

D. Software Engineering

At the end of the Programme, graduates should be able to:

i. demonstrate knowledge and understanding of essential facts, concepts, principles, and theories relating to Software Engineering;
ii. apply theoretical principles of Software Engineering in relevant areas; and
iii. apply appropriate methodologies, models and techniques that provide a basis for analysis, design, development, test and implementation, evaluation, maintenance and documentation of a large scale Software System.

MASTER'S DEGREE

At the end of the Programme, graduates should be able to:

i. apply and integrate knowledge concerning current research issues in computing and produce work that is at the forefront of developments in the domain of the programme of study;

ii. evaluate and analyse computing solutions in terms of their usability, efficiency and effectiveness;
iii. develop computing solutions and use necessary tools to analyse their performance;
iv. apply existing techniques of research and enquiry to acquire, interpret and extend, knowledge in computing;
v. communicate and function effectively in a group;
vi. prepare, publish and present technical material to a diverse audience; and
vii. demonstrate behaviour that is consistent with codes of professional ethics and responsibility.

DOCTORAL DEGREE

At the end of the Programme, graduates should be able to:

i. demonstrate a systematic comprehension and in-depth understanding of a discipline and mastery of skills and research methods related to the field of computing;
ii. critically analyse, evaluate and synthesise new and complex ideas;
iii. show scholarly capabilities to generate, design, implement and adopt the integral part of the research process based on the computing theoretical framework;
iv. contribute to original research that broadens the boundary of knowledge through an in-depth thesis, which has been presented and defended according to International standards including writing in Internationally refereed publications;
v. communicate to peers, scholarly communities and society at large through the preparation, publication and presentation of technical material;
vi. promote the technological, social and cultural progress in a knowledge-based society in both academic and professional contexts;
vii. demonstrate behaviour that is consistent with codes of professional ethics, legal requirements and responsibility; and
viii. supervise research projects.

CURRICULUM DESIGN AND DELIVERY

For the purpose of this Programme Standards, reference is made to the Code of Practice for Accreditation of Programmes (COPPA) and in particular, the section on 'Curriculum Design and Delivery'. "The term 'curriculum design and delivery' is used interchangeably with the term 'programme design and delivery'. "Programme" means an arrangement of Courses that are structured for a specified duration and learning volume to achieve the stated learning outcomes and usually leading to an award of a qualification" (COPPA, 2008, pp.12).

This section of the Programme Standards contains benchmarked statements pertaining to the structure and delivery of a programme within the field of Computing.

The matrices below represent the benchmark requirements for all levels of qualifications and they include the requirements for the various classifications of modules (e.g. core, concentration and electives). Specific requirement as to the body of knowledge for the different Levels (Certificate – Doctoral Degree) and Disciplines are provided in **Appendix A**.

This section of the Programme Standards provides as example the description and division relating to the Body of Knowledge, specific to the four Disciplines identified, Computer Science, Information Systems, Information Technology and Software Engineering. However, Higher Education Providers (HEPs) are encouraged to develop the Programme to reflect current best practices, achieve higher standards and develop specialisations.

CERTIFICATE

MINIMUM GRADUATING CREDIT - 60		
	Percentage	Credits*
Compulsory Modules (Bahasa Kebangsaan, Pengajian Malaysia, Pengajian Islam/Pendidikan Moral, etc.)	15-25	9-15
Core Modules/Common Core	**75-78**	**45-47**
Industrial Training	0-7	0-4

*Credits calculated are based on the Minimum Graduating Credit given above.

DIPLOMA

MINIMUM GRADUATING CREDIT - 90		
	Percentage	Credits*
Compulsory Modules (Bahasa Kebangsaan, Pengajian Malaysia, Pengajian Islam/Pendidikan Moral, etc.)	10-25	9-22
Core Modules/Common Core and Concentration/Specialisation	**58-68**	**52-61**
Core Modules/Common Core Concentration/Specialisation (Discipline Core)	24-39 19-44	21-35 17-40
Elective Modules	9-13	8-12
Industrial Training	4-13	4-12

*Credits calculated are based on the Minimum Graduating Credit given above.

BACHELOR'S DEGREE

MINIMUM GRADUATING CREDIT - 120		
	Percentage	Credits*
Compulsory Modules (Bahasa Kebangsaan, Pengajian Malaysia, Pengajian Islam/Pendidikan Moral, etc.)	8-25	9-30
Core Modules/Common Core and Concentration/Specialisation including a Project Paper	**46-73**	**55-88**
Core Modules/Common Core	18-29	22-35
Concentration/Specialisation (Discipline Core)	17-55	20-66
Elective Modules	9-24	11-29
Industrial Training	5-10	6-12

*Credits calculated are based on the Minimum Graduating Credit given above.

MASTER'S DEGREE by Coursework

MINIMUM GRADUATING CREDIT - 40		
	Percentage	Credits*
Total: **Core Modules/Common Core and Concentration/Specialisation**	**100**	**40**
Core Modules/Common Core including Research Methodology & a Project Paper	80-85	32-34
Elective Modules	15-20	6-8

* Credits calculated are based on the Minimum Graduating Credit given above.

MASTER'S DEGREE by Mixed mode

MINIMUM GRADUATING CREDIT - 40		
	Percentage	Credits*
Total: **Core Modules/Common Core and Concentration/Specialisation**	**100**	**40**
Core Modules/Common Core including Research Methodology & a Dissertation	50-70	20-28
Concentration/Specialisation	30-50	12-20

* Credits calculated are based on the Minimum Graduating Credit given above.

MASTER'S DEGREE by Research & DOCTORAL DEGREE

MINIMUM GRADUATING CREDIT - no given credit value
Research Methodology or relevant prerequisite modules as required.

STUDENT ASSESSMENT

"Student assessment is a crucial aspect of quality assurance because it drives student learning. It is one of the most important measures to show the achievement of learning outcomes. The result of assessment is also the basis in awarding qualifications. Hence, methods of student assessment have to be clear, consistent, effective, reliable and in line with current practices and must clearly support the achievement of learning outcomes" (COPPA, 2008, pp.15).

Specific methods of assessment will depend on the specific requirement of each module. However, as a general guide, the following must be considered:

- The combination of the various assessment methods should show the achievement of the Learning Outcomes;
- Summative and formative assessments should be used;
- Knowledge and understanding (the cognitive domain) should be tested through written, oral or other suitable means but practical skills should be tested by practical evaluation such as Lab Tests;
- In modules requiring practical skills, pass in practical evaluation is compulsory (A pass implies that the examiner is satisfied that the candidate has met the learning outcomes of the particular subject);
- The types of assessments indicated below are merely examples. Higher Education Providers (HEPs) are encouraged to use a variety of methods and tools appropriate for the learning outcomes and competencies; and
- Candidates must pass both continuous and final evaluation. A pass implies that the examiner must be satisfied that the candidate has met all the learning outcomes of the particular subject.

Generally, students shall be evaluated where appropriate through:

- Examination
  – Closed/Open book, Viva Voce, Mid, Semester;
- Coursework
  – Assignments, Quiz, Laboratory Report;
- Project
  – Individual/Group; and
- Others
  – Class Participation, Attendance, Group Activities, Presentation.

Suggested breakdown for each level of award from Certificate to Doctoral Degree are as given below:

QUALIFICATIONS	CONTINUOUS EVALUATION (%)	FINAL EVALUATION (%)	REQUIRED
Certificate	50-70	30-50	➢ Written Assessment ➢ Oral Assessment ➢ Practical Assessment
Diploma	50-70	30-50	➢ Written Assessment ➢ Oral Assessment ➢ Practical Assessment ➢ Industrial

			Attachment /Internship ➢ Project
Bachelor's Degree	40-70	30-60	➢ Written Assessment ➢ Oral Assessment ➢ Practical Assessment ➢ Case Studies ➢ Final Year Project ➢ Industrial Attachment /Internship ➢ Laboratory Reports ➢ Oral Presentation
Master's Degree by Coursework	-	-	➢ Written Assessment ➢ Presentation ➢ Project Paper
Master's Degree by Mixed mode	-	-	➢ Written Assessment ➢ Dissertation ➢ Presentation

			➢ Project Paper ➢ Viva Voce
Master's Degree by Research	-	-	➢ Presentation ➢ Thesis (two examiners) ➢ Viva Voce
Doctoral Degree	-	-	➢ Thesis (1 internal examiner and 1 external examiner) ➢ Viva Voce ➢ ONE (1) internationally refereed publication

STUDENT SELECTION

This section of the Programme Standards concerns the recruitment of students into the individual programme of study. In general, admission policies of the Programme need to comply with the prevailing policies of the Malaysian Ministry of Higher Education (MOHE). “There are varying views on the best method of student selection. Whatever the method used, the Higher Education Provider (HEP) must be able to defend its consistency. The number of students to be admitted to the Programme is determined by the capacity of the HEP and the number of qualified applicants. HEP admission and retention policies must not be compromised for the sole purpose of maintaining a desired enrolment. If an HEP operates geographically separated campuses or if the Programme is a collaborative one, the selection and assignment of all students must be consistent with national policies” (COPPA, 2008, pp.17).

The benchmarked standards for recruitment of students into Computing programmes are provided below. The standards are created keeping in mind the generic national Higher Education policies pertaining to minimum student entry requirement. Higher Education Provider (HEP) must take cognisance of any specific policies that may apply to their individual Institution.

CERTIFICATE

Pass Sijil Pelajaran Malaysia (SPM) or equivalent with ONE (1) credit, **AND** a Pass in Mathematics.

DIPLOMA

Pass Sijil Pelajaran Malaysia (SPM) or equivalent with at least THREE (3) credits, inclusive of Mathematics;

OR

Pass Sijil Tinggi Pelajaran Malaysia (STPM) or equivalent with at least ONE (1) principal in any subject **AND** credit in Mathematics at SPM level;

OR

Recognised Computing Certificate or equivalent;

OR

Recognised related Technical/Vocational Certificate or equivalent with ONE (1) year relevant work experience or ONE (1) semester Bridging Programme.

BACHELOR'S DEGREE

Recognised Matriculation or Foundation with CGPA 2.0 **AND** credit in Mathematics at SPM Level;

OR

Pass Sijil Pelajaran Malaysia (SPM) or equivalent with credit in Mathematics **AND**
Pass Sijil Tinggi Pelajaran Malaysia (STPM) with TWO (2) full passes or equivalent with minimum CGPA of 2.0;

OR

A Diploma in Computer Science, Information Systems, Information Technology, Software Engineering or equivalent with a minimum CGPA of 2.5.
Candidates with CGPA below 2.5 but above 2.0 may be admitted subject to a rigorous internal assessment process;

OR

Any other Diploma **with a minimum CGPA of 2.5, AND** credit in Mathematics at SPM level.

MASTER'S DEGREE

Master's Degree by Research

A Bachelor's Degree in Computing with CGPA of 2.5 and above.

Candidates with CGPA below 2.5 but above 2.0 may be admitted subject to a rigorous internal assessment process.

Master's Degree by Coursework or Mixed Mode

A Bachelor's Degree in Computing OR non-Computing field, with CGPA of 2.5 and above.

Where candidates without a Computing Degree are admitted, prerequisite modules in Computing must be offered to adequately prepare them for their advanced study.

Candidates with CGPA below 2.5 but above 2.0 may be admitted subject to a rigorous Internal Assessment process.

DOCTORAL DEGREE

A Master's Degree or equivalent **AND** candidates must have completed at least ONE (1) of their earlier Degrees (Master's or Bachelor's) in Computing.

ACADEMIC STAFF

"The quality of the academic staff is one of the most important components in assuring the quality of Higher Education and thus every effort must be made to establish proper and effective recruitment, service, development and appraisal policies that are conducive to staff productivity" (COPPA, 2008, pp.21).

The following sections provide benchmarked requirements for the various levels of the Computing qualifications.

CERTIFICATE

- Minimum qualification of the Academic staff-
  Diploma with TWO (2) years relevant industrial experience or professionally certified in the relevant area **OR** Bachelor's Degree in related field.
  (30% of the staff with minimum TWO (2) years relevant industrial work experience or professionally certified in the relevant area)
- Overall Staff-Student ratio – 1:20.
- Full-time and Part-time teaching faculty – At least 50% full-time.
- Continuous Professional Development (CPD) for full-time staff according to the specialisation needs with at least FIVE (5) days relevant training per year including conferences and workshops.
- Computer Lab Staff (Technicians)-Computer Lab ratio – 1:2.
- Computer Lab Demonstrator-Student ratio – 1:20.

DIPLOMA

- Minimum qualification of the Academic staff –
  Bachelor's Degree in related field.
  (30% of the staff with minimum TWO (2) years relevant industrial work experience or professionally certified in the relevant area)
- Overall Staff-Student ratio – 1:20.
- Full-time and Part-time teaching faculty – At least 60% full-time.

- Continuous Professional Development (CPD) for full-time staff according to the specialisation needs with at least FIVE (5) days relevant training per year including conferences and workshops.
- Computer Lab Staff (Technicians)-Computer Lab ratio – 1:2.
- Computer Lab Demonstrator-Student ratio – 1:20.

BACHELOR'S DEGREE

- Minimum qualification of the Academic Staff-
  - Master's Degree in the related field.
    (30% of the staff with minimum TWO (2) years relevant industrial work experience.)
  - Bachelor's Degree with FIVE (5) years related work experience in the subject taught.
    (The programme should not employ more than 20% of the staff of this category.)
- Overall Staff-Student ratio – 1:15.
- Full-time and Part-time teaching faculty – At least 60% full-time.
- Continuous Professional Development (CPD) for full-time staff according to the specialisation needs with at least FIVE (5) days relevant training per year including conferences and workshops.
- Computer Lab Staff (Technicians)-Computer Lab ratio – 1:2.
- Computer Lab Demonstrator-Student ratio – 1:20.

MASTER'S DEGREE

- Minimum qualification of the Academic staff-
  - Doctoral Degree in related field.
  - Master's Degree in related field with FIVE (5) years relevant work experience.
    (The Programme should not employ more than 20% of the staff in this category)
- Overall Staff-Student ratio – 1:10.
- Overall Supervisor-Student ratio – 1:7.
- Full-time and Part-time teaching faculty – At least 60% full-time.
- Continuous Professional Development (CPD) for full-time staff according to the specialisation needs with at least FIVE (5) days relevant training per year including conferences and workshops.

- Computer Lab Staff-Specialised Lab ratio – 1:1.

DOCTORAL DEGREE

- Minimum qualification of the Academic staff-
  - Doctoral Degree or equivalent in related field.
- Overall Supervisor-Student ratio – 1:7.
  The Main Supervisor must be a full-time staff.
- A Doctoral holder without experience may only act as the main supervisor with an experienced co-supervisor.
- Continuous Professional Development (CPD) for full-time staff according to the specialisation needs with at least FIVE (5) days relevant training per year including conferences and workshops.

EDUCATIONAL RESOURCES

"**Adequate educational resources are necessary to support the teaching-learning activities of the Programme**. These resources include finance, expertise, physical infrastructure, information and communication technology, and research facilities. The physical facilities of a programme are largely guided by the needs of the specific field of study" (COPPA, 2008, pp.23).

For Computing programmes, Higher Education Providers (HEPs) are required to provide sufficient resources conducive to support teaching and learning in the field. For lecture and tutorial rooms, and computer labs, sufficient space to accommodate student-centered learning must be provided. For research in Post-graduate programmes, candidates should be provided with a conducive work area.

CERTIFICATE & DIPLOMA

- Computer Labs
- Tutorial Rooms
- Lecture Rooms (with sufficient Audio Visual facilities)
- Library (including on-line resources)
- Internet Access
- Sufficient access to relevant software and hardware according to the needs of the Programmes and students

BACHELOR'S DEGREE

- Computer Labs
- Research/Project Lab for final year students Specialised Lab according to Programme needs
- Lecture Rooms (with sufficient Audio Visual facilities)
- Tutorial Rooms
- Library (including on-line resources)
- Internet Access

- Sufficient access to relevant software and hardware according to the needs of the Programmes and students

MASTER'S & DOCTORAL DEGREES

- Computer Labs
- Research/Project Lab
- Specialised Lab according to the Programme needs
- Lecture Rooms (with sufficient Audio Visual facilities)
- Tutorial Rooms
- Working Space/Station
- Library (including on-line resources)
- Internet Access
- Relevant specialised software and hardware according to the needs of the Programmes and students

LEADERSHIP, GOVERNANCE AND ADMINISTRATION

"There are many ways of administering an Educational Institution and the methods of management differ between HEPs. Nevertheless, governance that reflects the leadership of an Academic Organisation must emphasise excellence and scholarship. At the departmental level, it is crucial that the leadership provides clear guidelines and direction, builds relationships amongst the different constituents based on collegiality and transparency, manages finances and other resources with accountability, forge partnership with significant stakeholders in educational delivery, research and consultancy and dedicates itself to academic and scholarly endeavours. Whilst formalised arrangements can protect these relationships, they are best developed by a culture of reciprocity, mutuality and open communication" (COPPA, 2008, pp.28).

Specific to the level offered at the Institution, the Programme leader (e.g., Coordinator, Head or Dean) must fulfil the following qualifications and experience.

1. Diploma and Certificate

- A Bachelor's Degree in Computing or related area with a minimum of FIVE (5) years relevant experience.

2. Bachelor's Degree and below

- A Master's Degree with at least ONE (1) qualification in computing or related area.

3. Master's Degree and below

- A Doctoral Degree, with at least ONE (1) qualification in computing or related area;
  OR
- A Master's Degree with 10 years relevant experience, with at least ONE (1) qualification in computing or related area.

4. Doctoral Degree and below

- A Doctoral Degree with THREE (3) years experience in related area, with at least ONE (1) qualification in computing or related area;

OR

- A Master's Degree with 15 years relevant experience and actively involved in research and publication.

PROGRAMME MONITORING AND REVIEW

"Quality enhancement calls for programmes to be regularly monitored, reviewed and evaluated. This includes the monitoring, reviewing and evaluating of institutional structures and processes (administrative structure, leadership and governance, planning and review mechanisms), curriculum components (syllabi, teaching methodologies, learning outcomes) as well as student progress, employability and performance.

Feedback from multiple sources - students, alumni, academic staff, employers, professional bodies, parents - assist in enhancing the quality of the programme. Feedback can also be obtained from an analysis of student performance and from longitudinal studies.

Measures of student performance would include the average study duration, assessment scores, passing rate at examinations, success and dropout rates, students' and alumni's report about their learning experience, as well as time spent by students in areas of special interest. Evaluation of student performance in examinations can reveal very useful information. If student selection has been correctly done, a high failure rate in a programme, indicates something amiss in the curriculum content, teaching-learning activities or assessment system. The programme committees need to monitor the performance rate in each programme and investigate if the rate is too high or too low.

Student feedback, for example, through questionnaires and representation in programme committees, is useful for identifying specific problems and for continual improvement of the programme.

One method to evaluate programme effectiveness is a longitudinal study of the graduates. The department should have mechanisms for monitoring the performance of its graduates and for obtaining the perceptions of society and employers on the strengths and weaknesses of the graduates and to respond appropriately" (COPPA, 2008, pp.27).

CONTINUAL QUALITY IMPROVEMENT

"Increasingly, society demands greater accountability from HEPs. Needs are constantly changing because of the advancements in science and technology, and the explosive growth in global knowledge, which are rapidly and widely disseminated. In facing these challenges, HEPs have little choice but to become dynamic learning organisations that need to continually and systematically review and monitor the various issues so as to meet the demands of the constantly changing environment" (COPPA, 2008, pp.30-31).

The Higher Education Providers (HEPs) are expected to provide evidence of ability to keep pace with changes in the field and requirements of stakeholders. These may be demonstrated by, but not limited to:

1. annual module review & programme curriculum review, conducted at least ONCE every 2-3 years;
2. appointment of external reviewer/industrial adviser for quality assessment processes;
3. linkages with industry;
4. continuous review of industrial attachment practices and records;
5. dialogue sessions with stakeholders;
6. active participation of academic staff at relevant conferences, seminars, workshops and short courses;
7. presentations by invited speakers, local or international; and
8. organisation of conferences, seminars and workshops.

APPENDIX A

BODY OF KNOWLEDGE

The breath and depth of the required Computing (ICT) Body of Knowledge should reflect the different level of study from Certificate to Doctoral Degree level. Higher Education Providers (HEPs) are required to develop programmes to reflect current best practices. Institutions are advised to refer to the Association of Computing Machinery (ACM) website or other relevant Computing Curricula and Description.

COMMON CORES FOR COMPUTING

(A) CERTIFICATE

Body of Knowledge	Detail Topics
Computer Architecture	• Computer Systems • Data Representation and Manipulation • Registers • Memory Organization • Bus Configurations • Timing Issues and Pipelining • Assembly Language
Database	• Database Concepts • Normalization • Data Models • Database Management Systems • Introduction to SQL
Mathematics	• Number base systems • Control of accuracy • Formal Language • Set, Relation and Function • Counting Principle • Logic, truth tables

	• Boolean Algebra • Graphs & Trees
Net-Centric Computing	• Data Communication and Transmission • Classifying Networks • LANs and WANs • Networking and Internetworking devices • Broadcasting Communications/Voice Over IP /Telecommunications • Network Protocols and Standards • Modulation and Multiplexing • Switching • Socket Programming
Operating Systems	• Hardware and Software • System Software and Architecture • Process Control Management • Deadlocks • Memory Management • I/O Management • File System Management • System Security • Network Operating System
Programming Fundamentals	• Problem Solving and Program Design • Programming Language concepts • Control Structures • Operators • Arrays • Functions / Methods • String Manipulation • Pointer expression / arithmetic • Development of Graphical User Interface
System Analysis and Design	• Fundamentals of SAD • Project Management • Overview of SDLC

	• Preliminary Investigation/Feasibility Study • Systems Analysis • Data Flow Diagrams • Data Dictionary • Process Specification • Input/Output Design

(B) DIPLOMA

Body of Knowledge	Detail Topics
Computer Architecture	• Computer Systems • Data Representation and Manipulation • Registers • Memory Organization • Bus Configurations • Timing Issues and Pipelining • Assembly Language
Database	• Database Concepts • Normalization • Data Models • Database Management Systems • Introduction to SQL
Mathematics	• Number base systems • Control of accuracy • Formal Language • Set, Relation and Function • Counting Principle • Logic, truth tables • Boolean Algebra • Graphs & Trees

Net-Centric Computing	• Data Communication and Transmission • Classifying Networks • LANs and WANs • Networking and Internetworking devices • Broadcasting Communications/Voice Over IP /Telecommunications • Network Protocols and Standards • Modulation and Multiplexing • Switching • Socket Programming
Operating Systems	• Hardware and Software • System Software and Architecture • Process Control Management • Deadlocks • Memory Management • I/O Management • File System Management • System Security • Network Operating System
Programming Fundamentals	• Problem Solving and Program Design • Programming Language concepts • Control Structures • Operators • Arrays • Functions / Methods • String Manipulation • Pointer expression / arithmetic • Development of Graphical User Interface
System Analysis and Design	• Fundamentals of SAD • Project Management • Overview of SDLC • Preliminary Investigation/Feasibility Study • Systems Analysis

	• Data Flow Diagrams • Data Dictionary • Process Specification • Input/Output Design

(C) BACHELOR'S DEGREE

Body of Knowledge	Detail Topics
Architecture and Organisation	• Digital Logic • Data Representation • Assembly Level Organisation • Memory Architecture • Functional Organisation • Multiprocessing
Information Management	• Information Models • Database Systems • Data Modelling • Relational Databases • Query Languages • Relational Database Design • Transaction Processing • Distributed Databases • Physical Database Design
Mathematics	• Discrete Structures • Functions Relations And Sets • Basic Logic Proof Techniques • Basics of Counting • Graphs and Trees • Discrete Probability • Statistics and Probability • Calculus

	• Linear Algebra
Net-Centric Computing	• Network Communication • Network Security • Web Organization • Networked Applications • Network Management • Multimedia Technologies • Mobile Computing
Operating Systems	• Overview of Operating Systems • Operating System Principles • Concurrency • Scheduling and Dispatch • Memory Management
Programming Fundamentals	• Fundamental Constructs • Algorithmic Problem Solving • Data Structures • Recursion • Event Driven Programming • Object Oriented • Foundations of Information Security • Secure Programming
Software Analysis and Design	• Modelling foundations • Types of models • Analysis fundamentals • Requirements fundamentals • Requirements specification & documentation • Requirements validation • Design concepts • Design strategies • Architectural design • Human computer interface design • Detailed design • Design support tools and evaluation

COMMON CORES FOR THE FOUR (4) DISCIPLINES OF COMPUTING

(A) Computer Science

Body of Knowledge	Detail Topics
Algorithms and Complexity	• Basic Analysis • Algorithmic Strategies • Fundamental Algorithms • Distributed Algorithms • Basic Computability
Programming Languages	• Overview of Programming Languages • Virtual Machines • Basic Language Translation • Declarations and Types • Abstraction Mechanisms • Object Oriented Programming • Programming Language Semantics
Human-Computer Interaction	• Foundations • Building GUI Interfaces • User-Centred Software Evaluation • User-Centred Software Development • GUI Design • GUI Programming • Human Factors and Security
Graphics and Visual Computing	• Fundamental Techniques • Graphic Systems • Geometric Modeling • Basic Rendering • Computer Animation • Visualization • Virtual Reality • Game Engine Programming

Intelligent Systems	• Fundamental Issues • Basic Search Strategies • Knowledge Based Reasoning • Advanced Search • Agents • Machine Learning • Robotics
Social and Professional Issues	• Social Context • Analytical Tools • Professional Ethics • Risks • Security Operations • Intellectual Property • Privacy and Civil Liberties • Computer Crime
Software Engineering	• Software Design • Using APIs • Tools and Environments • Software Processes • Requirements Specifications • Software Validation • Software Evolution • Software Project Management • Software Reliability • Risk Assessment
Computational Science	• Modelling and Simulation • Operations Research • Parallel Computation

(B) Information Systems

Body of Knowledge	Detail Topics
Information Technology	• Computer Architectures • Algorithms and Data Structures • Programming Languages • Operating Systems • Telecommunications • Database • Artificial Intelligence
Organisational and Management Concepts	• General Organisation Theory • Information Systems Management • Decision Theory • Organisational Behavior • Managing the Process of Change • Legal and Ethical Aspects of IS • Professionalism • Interpersonal Skills
Theory and Development of Systems	• Approaches to Systems Development • Systems Development Concepts and Methodologies • Systems Development Tools and Techniques • Application Planning • Risk Management • Project Management • Information and Business Analysis • Information Systems Design • Systems Implementation and Testing Strategies • Systems Operation and Maintenance • Systems Development for Specific Types of Information Systems

(C) Information Technology

Body of Knowledge	Detail Topics
Information Technology Fundamentals	• Pervasive Themes in IT • History of Information Technology • IT and Its Related and Informing Disciplines • Application Domains
Human Computer Interaction	• Human Factors • HCI Aspects of Application Domains • Human-Centred Evaluation • Developing Effective Interfaces • Accessibility • Emerging Technologies • Human-Centred Software Development
Information Assurance and Security	• Fundamental Aspects • Security Mechanisms (Countermeasures) • Operational Issues • Policy • Attacks • Security Domains • Forensics • Information States • Security Services • Threat Analysis Model • Vulnerabilities
Integrative Programming & Technologies	• Inter-systems Communications • Data Mapping and Exchange • Integrative Coding • Scripting Techniques • Software Security Practices • Miscellaneous Issues • Overview of Programming Languages
System Administration	• Operating Systems

and Maintenance	• Applications • Administrative Activities • Administrative Domains
System Integration and Architecture	• Requirements • Acquisition and Sourcing • Integration and Deployment • Project Management • Testing and Quality Assurance • Organizational Context • Architecture
Social and Professional Issues	• Professional Communications • Teamwork Concepts and Issues • Social Context of Computing • Intellectual Property • Legal Issues in Computing • Organizational Context • Professional and Ethical Issues and Responsibilities • History of Computing • Privacy and Civil Liberties
Web Systems and Technologies	• Web Technologies • Information Architecture • Digital Media • Web Development • Vulnerabilities

(D) Software Engineering

Body of Knowledge	Detail Topics
Computing Essentials	• Computer Science foundations • Construction technologies • Construction tools • Formal construction methods
Mathematical & Engineering Fundamentals	• Mathematical foundations • Engineering foundations for software development • Engineering economics for software
Professional Practice	• Group dynamics / psychology • Communications skills (specific to SE) • Professionalism
Software Modelling & Analysis	• Modelling foundations • Types of models • Analysis fundamentals • Requirements fundamentals • Eliciting requirements • Requirements specification & documentation • Requirements validation
Software Design	• Design concepts • Design strategies • Architectural design • Human computer interface design • Detailed design • Design support tools and evaluation
Software V & V	• V&V terminology and foundations • Reviews • Testing • Human computer UI testing and evaluation • Problem analysis and reporting
Software Evolution	• Evolution processes

	• Evolution activities
Software Process	• Process concepts • Process implementation
Software Quality	• Software quality concepts and culture • Software quality standards • Software quality processes • Process assurance • Product assurance
Software Management	• Management concepts • Project planning • Project personnel and organization • Project control • Software configuration management